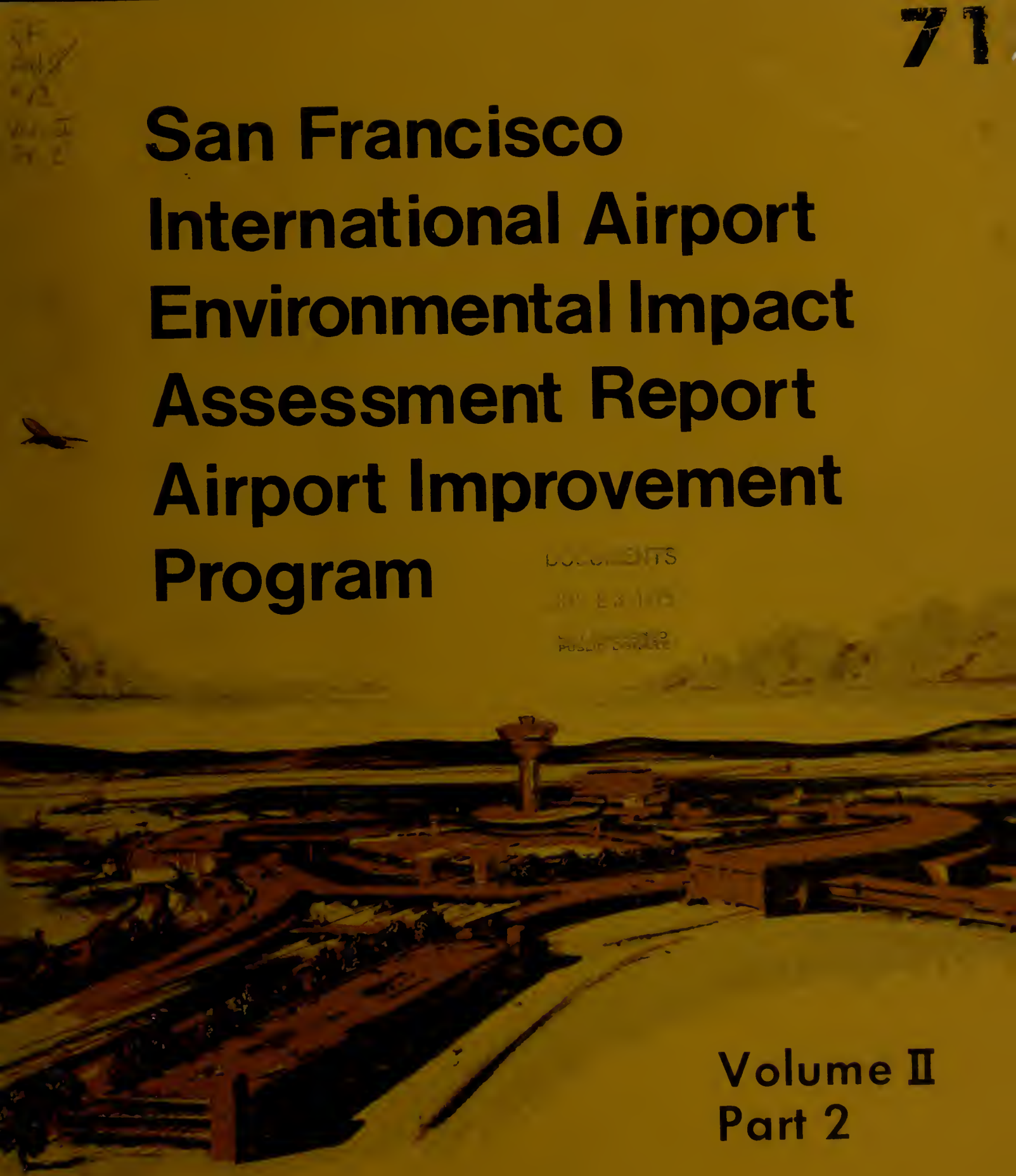
71

San Francisco International Airport Environmental Impact Assessment Report Airport Improvement Program

DOCUMENTS
PUBLIC LIBRARY



Volume II
Part 2

Landrum & Brown, Airport Consultants

May 1975

5/S

DOCUMENTS

SAN FRANCISCO
PUBLIC LIBRARY

REFERENCE
BOOK

Not to be taken from the Library

SAN FRANCISCO PUBLIC LIBRARY
3 1223 04180 0740

San Francisco Airports Commission

SAN FRANCISCO INTERNATIONAL AIRPORT

EXPANSION PROGRAM

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

VOLUME II

Part 2

Prepared by:

Landrum & Brown
Airport Consultants

May, 1975

D REF 387.736 Sa524e
v.2 pt.2

San Francisco
International Airport
1975.

3 1223 04180 0740

S.F. PUBLIC LIBRARY

THIS VOLUME IS DIVIDED INTO TWO PARTS

PART 1 CONTAINS:

- APPENDIX A - UPDATE OF THE AIRPORT FACILITY REQUIREMENTS DATA BASE
- APPENDIX B - NOISE IMPACT
- APPENDIX C - GROUND ACCESS

PART 2 CONTAINS:

- APPENDIX D - AIR QUALITY
- APPENDIX E - WATER USAGE AND WASTE WATER GENERATION
- APPENDIX F - GEOLOGICAL ASPECTS OF THE SAN FRANCISCO INTERNATIONAL AIRPORT EXPANSION PROGRAM
- APPENDIX G - OTHER ISSUES
- APPENDIX H - ANALYSIS OF BENEFITS AND COSTS

TABLE OF CONTENTS

		Page
APPENDIX A - UPDATE OF THE AIRPORT FACILITY REQUIREMENTS DATA BASE		
1.	INTRODUCTION	A-1
2.	THE ELEMENTS OF AVIATION DEMAND	A-2
3.	AIR PASSENGER FORECASTS	A-10
4.	FORECASTS OF OPERATIONS AND FLEET MIX	A-14
5.	THE "DO-NOTHING" FORECAST	A-26
6.	PURPOSE AND SCOPE OF THE DEMAND/CAPACITY ANALYSIS	A-29
7.	AIRFIELD DEMAND/CAPACITY ANALYSIS METHODOLOGY	A-30
8.	FINDINGS OF THE AIRFIELD DEMAND/CAPACITY ANALYSIS	A-39
9.	AIRPORT FACILITY REQUIREMENTS	A-39
APPENDIX B - NOISE IMPACT		
1.	INTRODUCTION	B-1
2.	GENERAL DISCUSSION OF NOISE IMPACT ANALYSIS	B-2
3.	DESCRIPTION OF METHODOLOGY	B-15
4.	INPUT REQUIREMENTS	B-21
5.	IMPACT ANALYSIS	B-45

TABLE OF CONTENTS

		Page
APPENDIX C - GROUND ACCESS		
1.	INTRODUCTION	C-2
2.	ACCESS FACILITIES	C-6
3.	METHODOLOGY	C-10
4.	SIMULATION OF DESIGN DAY CONDITIONS - 1974	C-23
5.	SIMULATION OF DESIGN DAY TRAFFIC - 1982	C-28
6.	SIMULATION OF DESIGN DAY TRAFFIC - 1990	C-31
7.	IMPACT ASSESSMENT	C-37
8.	MITIGATING MEASURES	C-63
9.	SUMMARY AND CONCLUSIONS	C-66
APPENDIX D - AIR QUALITY		
1.	INTRODUCTION	D-2
2.	LOCAL SETTING	D-7
3.	AIRPORT ACTIVITIES	D-16
4.	EVALUATION METHODOLOGY	D-24
5.	IMPACT ASSESSMENT	D-37
APPENDIX E - WATER USAGE AND WASTE WATER GENERATION		
1.	INTRODUCTION	E-1
2.	WATER REQUIREMENTS	E-2
3.	WASTE WATER GENERATION	E-5
4.	IMPACT OF FUTURE DEVELOPMENTS	[illegible]

TABLE OF CONTENTS

		Page
APPENDIX F -	GEOLOGICAL ASPECTS OF THE SAN FRANCISCO INTERNATIONAL AIRPORT EXPANSION PROGRAM	
1.	INTRODUCTION	F-1
2.	GEOLOGY OF BAY AREA	F-2
3.	SEISMIC EFFECTS	F-8
4.	TSUNAMI AND SEICH EFFECTS	F-11
5.	IMPACT ASSESSMENT	F-13
APPENDIX G -	OTHER ISSUES	
1.	INTRODUCTION	G-1
2.	AESTHETICS	G-2
3.	FUEL AND ENERGY	G-6
4.	BAY FILL	G-18
5.	HYDROLOGICAL CONSIDERATIONS	G-19
6.	SOLID WASTES	G-20
7.	WILDLIFE	G-24
8.	RECREATIONAL SITES	G-27
9.	HISTORICAL SITES	G-30

TABLE OF CONTENTS

		Page
APPENDIX H - ANALYSIS OF BENEFITS AND COSTS		
1.	INTRODUCTION	H-1
2.	APPROACH TO THE PROBLEM	H-3
3.	DESCRIPTION OF THE STUDY AREA	H-5
4.	ENVIRONMENTAL EFFECTS	H-6
5.	GROUND ACCESS EFFECTS	H-18
6.	SOCIO-ECONOMIC EFFECTS	H-25
7.	SUMMARY OF BENEFITS AND COSTS	H-40

LIST OF EXHIBITS

Exhibit	Title	Following Page
A-1	SUMMARY OF PREVIOUS AVIATION DEMAND FORECASTS	A-5
A-2	FORECASTS OF TOTAL ANNUAL ON AND OFF PASSENGERS	A-10
A-3	FORECASTS OF AVERAGE SEATS PER OPERATION	A-15
A-4	DERIVATION OF 1973 AVERAGE SEATS PER OPERATION	A-17
A-5	FORECASTS OF ANNUAL BOARDING LOAD FACTOR	A-19
A-6	SUMMARY OF PASSENGER AND OPERATIONS FORECASTS	A-21
A-7	AIRCRAFT FLEET MIX FORECAST	A-23
A-8	AIRSPACE DEFINITIONS	A-32
A-9	OPERATING CONFIGURATIONS/PERCENT UTILIZATIONS	A-34
A-10	RUNWAY RATINGS	A-36
A-11	INVENTORY OF NAVIGATIONAL AIDS	A-37
A-12	AIRCRAFT CLASSIFICATIONS	A-39
A-13	HOURLY CAPACITY DATA	A-40
A-14	ANNUAL CAPACITY AND DELAY	A-41

LIST OF EXHIBITS

Exhibit	Title	Following Page
B-1	TYPICAL FLYOVER SIGNAL	B-5
B-2	PLANNING GUIDELINES	B-10
B-3	MARCO FLOW CHART OF CNEL COMPUTER PROGRAM LOGIC	B-17
B-4	ASDS SINGLE EVENT SOUND CONTOUR, B-727-100	B-19
B-5	RUNWAY DISTRIBUTIONS BY TIME OF DAY	B-22
B-6	DAILY OPERATIONS	B-26
B-7	AIRCRAFT TYPES USED FOR ASDS ANALYSIS	B-27
B-8	STAGE LENGTH DISTRIBUTION	B-29
B-9	TAKEOFF WEIGHTS FOR ASDS	B-30
B-10	FLIGHT TRACK GEOMETRY	B-32
B-11	DEPARTURE FLIGHT TRACK DISTRIBUTIONS	B-34
B-12	FLIGHT TRACK SEGMENTS	B-35
B-13	FLIGHT TRACK SEGMENTS DISTRIBUTION	B-36
B-14	EXAMPLE OF INPUT DATA	B-40
B-15	LAND USE MAP	B-48
B-16	STUDY ZONES	B-49
B-17	POPULATION AND DWELLING UNIT PARAMETERS	B-51
B-18	1974 CNEL AVERAGE ANNUAL DAY NOISE CONTOURS	B-52

LIST OF EXHIBITS

Exhibit	Title	Following Page
B-19	1974 CNEL AVERAGE SEASONAL DAY NOISE CONTOURS	B-53
B-20	1974 ASDS AVERAGE ANNUAL DAY NOISE CONTOURS	B-55
B-21	1974 ASDS AVERAGE SEASONAL DAY NOISE CONTOURS	B-56
B-22	NOISE IMPACT SUMMARY CNEL 1974	B-58
B-23	NOISE IMPACT SUMMARY ASDS 1974	B-59
B-24	1982 CNEL AVERAGE ANNUAL DAY NOISE CONTOURS	B-60
B-25	1982 CNEL AVERAGE SEASONAL DAY NOISE CONTOURS	B-61
B-26	1982 ASDS AVERAGE ANNUAL DAY NOISE CONTOURS	B-62
B-27	1982 ASDS AVERAGE SEASONAL DAY NOISE CONTOURS	B-64
B-28	NOISE IMPACT SUMMARY CNEL 1982	B-65
B-29	NOISE IMPACT SUMMARY ASDS 1982	B-66
B-30	1990 AVERAGE ANNUAL DAY CNEL CONTOURS	B-68
B-31	1990 AVERAGE SEASONAL DAY CNEL CONTOURS	B-69
B-32	1990 AVERAGE ANNUAL DAY ASDS CONTOURS	B-70
B-33	1990 AVERAGE SEASONAL DAY ASDS CONTOURS	B-71
B-34	NOISE IMPACT SUMMARY CNEL 1990	B-72

LIST OF EXHIBITS

Exhibit	Title	Following Page
B-35	NOISE IMPACT SUMMARY ASDS 1990	B-73
B-36	CNEL SUMMARY	B-79
B-37	ASDS SUMMARY	B-80
B-38	NOISE IMPACT SUMMARY	B-81
C-1	ACCESS FACILITIES	C-6
C-2	EXISTING PARKING FACILITIES	C-10
C-3	VEHICLE OCCUPANCY RATES	C-12
C-4	1974 SURVEY DAY AIR PASSENGERS	C-18
C-5	1974 SURVEY DAY ESTIMATED EMPLOYMENT DISTRIBUTION BY CATEGORY	C-19
C-6	1974 SURVEY DAY AIRPORT POPULATION	C-20
C-7	1974 SURVEY DAY TOTAL PERSON TRIPS	C-20
C-8	1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL AIR PASSENGERS PERSON TRIPS	C-21
C-9	1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL NON-AIR PASSENGER PERSON TRIPS	C-21
C-10	1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL EMPLOYEE PERSON TRIPS	C-21
C-11	1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS	C-21
C-12	1974 SURVEY DAY TOTAL VEHICLE TRIPS	C-22

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-13	SURVEY DAY TRAFFIC	C-22
C-14	1974 DESIGN DAY AIR PASSENGERS	C-24
C-15	1974 DESIGN DAY AIRPORT POPULATION	C-24
C-16	1974 DESIGN DAY TOTAL PERSON TRIPS	C-24
C-17	1974 DESIGN DAY MODE SPLIT DISTRIBUTION TOTAL AIR PASSENGER PERSON TRIPS	C-25
C-18	1974 DESIGN DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS	C-26
C-19	1974 DESIGN DAY TOTAL VEHICLE TRIPS	C-26
C-20	1974 DESIGN DAY TRAFFIC	C-26
C-21	1974 DESIGN DAY TRAFFIC	C-26
C-22	1974 AVERAGE ANNUAL DAILY TRAFFIC	C-27
C-23	1974 AVERAGE ANNUAL DAILY TRAFFIC	C-27
C-24	1982 DESIGN DAY ESTIMATED AIRPORT POPULATION	C-29
C-25	1982 DESIGN DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS	C-30
C-26	1982 DESIGN DAY TOTAL VEHICLE TRIPS	C-30
C-27	1982 DESIGN DAY TRAFFIC	C-31
C-28	1982 DESIGN DAY TRAFFIC	C-31
C-29	1982 AVERAGE ANNUAL DAILY TRAFFIC	C-31
C-30	1982 AVERAGE ANNUAL DAILY TRAFFIC	C-31

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-31	1990 DESIGN DAY AIRPORT POPULATION	C-31
C-32	1990 DESIGN DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS WITHOUT RAPID TRANSIT	C-32
C-33	1990 DESIGN DAY TOTAL VEHICLE TRIPS WITHOUT RAPID TRANSIT	C-33
C-34	1990 DESIGN DAY TRAFFIC WITHOUT RAPID TRANSIT	C-33
C-35	1990 DESIGN DAY TRAFFIC WITHOUT RAPID TRANSIT	C-33
C-36	1990 AVERAGE ANNUAL DAILY TRAFFIC WITHOUT RAPID TRANSIT	C-33
C-37	1990 AVERAGE ANNUAL DAILY TRAFFIC WITHOUT RAPID TRANSIT	C-33
C-38	RAPID TRANSIT EXTENSION - DALY CITY TO AIRPORT	C-34
C-39	1990 DESIGN DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS WITH RAPID TRANSIT	C-35
C-40	1990 DESIGN DAY TOTAL VEHICLE TRIPS WITH RAPID TRANSIT	C-35
C-41	1990 DESIGN DAY TRAFFIC WITH RAPID TRANSIT	C-36
C-42	1990 DESIGN DAY TRAFFIC WITH RAPID TRANSIT	C-36
C-43	1990 AVERAGE ANNUAL DAILY TRAFFIC WITH RAPID TRANSIT	C-36
C-44	1990 AVERAGE ANNUAL DAILY TRAFFIC WITH RAPID TRANSIT	C-36

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-45	ON-AIRPORT ROADWAY DESIGNATIONS	C-39
C-46	ON-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-39
C-47	OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-40
C-48	1974 DESIGN DAY PEAK HOUR WEAVING SECTION ANALYSIS MAIN ACCESS ROADWAY	C-40
C-49	PARKING GENERATION FACTORS	C-41
C-50	RATIOS OF PEAK ACCUMULATIONS TO TOTAL WEEKLY PARKERS	C-41
C-51	AIRPORT PARKERS FOR TYPICAL WEEK IN AUGUST	C-43
C-52	1974 GARAGE ANALYSIS ACCUMULATION OF PARKED VEHICLES	C-43
C-53	1974 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - SOUTH TERMINAL	C-44
C-54	1974 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - SOUTH TERMINAL	C-44
C-55	1974 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - CENTRAL TERMINAL	C-44
C-56	1974 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - CENTRAL TERMINAL	C-44
C-57	1974 DESIGN DAY OFF-AIRPORT HIGHWAY UTILIZATION	C-46
C-58	1982 DESIGN DAY PEAK HOUR ON AIRPORT INTERSECTION CAPACITY ANALYSIS	C-48

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-59	1982 DESIGN DAY OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-49
C-60	1982 DESIGN DAY PEAK HOUR WEAVING SECTION ANALYSIS MAIN ACCESS ROADWAY	C-49
C-61	1982 DESIGN CONDITIONS AIRPORT PARKERS FOR TYPICAL WEEK IN AUGUST	C-51
C-62	1982 GARAGE ANALYSIS ACCUMULATION OF PARKED VEHICLES	C-51
C-63	1982 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - WITHOUT EXPANSION	C-52
C-64	1982 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - WITHOUT EXPANSION	C-53
C-65	1982 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - WITH EXPANSION	C-53
C-66	1982 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - WITH EXPANSION	C-53
C-67	1982 DESIGN DAY OFF-AIRPORT HIGHWAY UTILIZATION	C-54
C-68	1990 DESIGN DAY PEAK HOUR ON-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-55
C-69	1990 DESIGN DAY OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-56
C-70	1990 DESIGN DAY PEAK HOUR WITHOUT RAPID TRANSIT WEAVING SECTION ANALYSIS MAIN ACCESS ROADWAY	C-56

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-71	1990 DESIGN DAY PEAK HOUR WITH RAPID TRANSIT WEAVING SECTION ANALYSIS MAIN ACCESS ROADWAY	C-57
C-72	1990 DESIGN CONDITIONS AIRPORT PARKERS FOR TYPICAL WEEK IN AUGUST	C-58
C-73	1990 GARAGE ANALYSIS ACCUMULATION OF PARKED VEHICLES - WITHOUT RAPID TRANSIT	C-58
C-74	1990 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - WITHOUT EXPANSION	C-60
C-75	1990 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - WITHOUT EXPANSION	C-60
C-76	1990 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - WITH EXPANSION	C-60
C-77	1990 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - WITH EXPANSION	C-60
C-78	1990 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - WITH EXPANSION AND RAPID TRANSIT	C-61
C-79	1990 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - WITH EXPANSION AND RAPID TRANSIT	C-61
C-80	1990 DESIGN DAY WITHOUT RAPID TRANSIT OFF-AIRPORT HIGHWAY UTILIZATION	C-62
C-81	1990 DESIGN DAY WITH RAPID TRANSIT OFF-AIRPORT HIGHWAY UTILIZATION	C-62
C-82	SUMMARY OF ON-AIRPORT INTERSECTION LEVEL OF SERVICE FOR ALTERNATIVE CONDITIONS	C-66

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-83	SUMMARY OF DESIGN DAY OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-67
C-84	SUMMARY OF WEAVING SECTION ANALYSIS SOUTH RAMPS - MAIN ROADWAY DESIGN DAY - PEAK HOUR	C-68
C-85	ANALYSIS OF PUBLIC PARKING FACILITIES	C-70
C-86	SUMMARY OF CURB FRONTAGE ANALYSIS	C-70
C-87	OFF-AIRPORT HIGHWAY UTILIZATION	C-71
D-1	HISTORY AND TRENDS IN AMBIENT AIR QUALITY	D-8
D-2	SUMMARY OF IMPACT OF CONTROL STRATEGIES IN SAN FRANCISCO BAY REGION IN 1977	D-8
D-3	HIGH HOUR OXIDANT CONCENTRATIONS AT BURLINGAME	D-9
D-4	MONTHLY AVERAGE HIGH HOUR CARBON MONOXIDE CONCENTRATIONS AT BURLINGAME	D-9
D-5	AVERAGE OF MONTH'S 24 HOUR SULPHUR DIOXIDE MEASUREMENTS AT BURLINGAME	D-9
D-6	MAXIMUM OF MONTH'S 24 HOUR SUSPENDED PARTICULATE MEASUREMENTS AT BURLINGAME	D-9
D-7	MONTHLY AVERAGE OF HIGH HOUR NITROGEN DIOXIDE MEASUREMENTS AT REDWOOD CITY	D-9
D-8	PERCENTAGE FREQUENCY OF INVERSIONS AT 3500 FEET OR LESS	D-12
D-9	VISIBILITY AND CIRCULATION PATTERNS	D-13

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-10	NORTH WIND FLOW PATTERNS	D-13
D-11	NORTHEAST WIND FLOW PATTERNS	D-13
D-12	EAST WIND FLOW PATTERNS	D-13
D-13	SOUTHEAST WIND FLOW PATTERNS	D-13
D-14	SOUTH WIND FLOW PATTERNS	D-13
D-15	SOUTHWEST WIND FLOW PATTERNS	D-13
D-16	WEST WIND FLOW PATTERNS	D-13
D-17	NORTHWEST WIND FLOW PATTERNS	D-13
D-18	JANUARY MEAN MAXIMUM TEMPERATURES	D-14
D-19	JANUARY MEAN MINIMUM TEMPERATURES	D-14
D-20	JULY MEAN MAXIMUM TEMPERATURES	D-14
D-21	JULY MEAN MINIMUM TEMPERATURES	D-14
D-22	MEAN ANNUAL TOTAL PRECIPITATION	D-15
D-23	AIR POLLUTION POTENTIAL FOR AREAS AROUND MAJOR AIRPORT SITES	D-16
D-24	AVERAGE ANNUAL EMISSIONS FROM TRANSPORTATION SECTOR	D-17
D-25	SCHEMATIC DESCRIPTION OF DEMANDS AND SOURCE OF AIR POLLUTION	D-18
D-26	EMISSION CHARACTERISTIC OF AIRCRAFT ENGINES	D-18

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-27	TRENDS IN CIVILIAN AIRCRAFT EMISSIONS 1950 - 1980	D-18
D-28	EMISSION OF AIR POLLUTANTS FOR HEATING PLANT	D-22
D-29	AIRPORT AIR QUALITY DISPERSION MODEL FUNCTIONAL FLOW DIAGRAM	D-26
D-30	FIELD MEASUREMENT LOCATIONS	D-30
D-31	CARBON MONOXIDE MONITORING DATA	D-31
D-32	METEOROLOGICAL SCENARIOS EVALUATED IN DISPERSION MODELING	D-33
D-33	FREQUENCY OF METEOROLOGICAL CONDITIONS BY WIND DIRECTION AND STABILITY CLASS ANNUAL 0700 - 1000 HOURS	D-33
D-34	FREQUENCY OF METEOROLOGICAL CONDITIONS BY WIND DIRECTION AND STABILITY CLASS DEC.-FEB. 1300 TO 1600 HOURS	D-33
D-35	FREQUENCY OF METEOROLOGICAL CONDITIONS BY WIND DIRECTION AND STABILITY CLASS DEC.-FEB. 0700 - 1000 HOURS	D-33
D-36	GROUND VEHICLE CARBON MONOXIDE, HYDRO-CARBON, NITROGEN OXIDE, PARTICULATE AND SULPHUR DIOXIDE EMISSION FACTORS BY MODE OF OPERATION	D-34
D-37-1	AIRCRAFT CARBON MONOXIDE EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974	D-34

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-37-2	AIRCRAFT HYDROCARBON EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974	D-34
D-37-3	AIRCRAFT NITROGEN OXIDES EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974	D-34
D-37-4	AIRCRAFT PARTICULATES EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974	D-34
D-37-5	AIRCRAFT SULPHUR OXIDES EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974	D-34
D-38-1	STATIONARY SOURCES EMISSION FACTORS	D-34
D-38-2	STATIONARY SOURCES EMISSION FACTORS	D-34
D-38-3	STATIONARY SOURCES EMISSION FACTORS	D-34
D-39	COMPARISON OF MEASURED AND CALCULATED CARBON MONOXIDE CONCENTRATIONS	D-35
D-40	AIR QUALITY EVALUATION SCENARIOS	D-35
D-41	AMBIENT AIR QUALITY STANDARDS	D-38
D-42	1974 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS EXISTING AIRPORT	D-41
D-43	1982 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-44	1982 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT	D-41

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-45	1990 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-46	1990 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/O BART	D-41
D-47	1990 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/BART	D-41
D-48	1974 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS EXISTING AIRPORT	D-41
D-49	1982 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-50	1982 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT	D-41
D-51	1990 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-52	1990 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/O BART	D-41
D-53	1990 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/BART	D-41
D-54	1974 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS EXISTING AIRPORT	D-41

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-55	1982 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-56	1982 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT	D-41
D-57	1990 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-58	1990 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/O BART	D-41
D-59	1990 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/BART	D-41
D-60	1974 PARTUCLATES ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS EXISTING AIRPORT	D-41
D-61	1982 PARTICULATE ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-62	1982 PARTICULATE ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT	D-41
D-63	1990 PARTICULATE ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS NO FURHTER DEVELOPMENT	D-41
D-64	1990 PARTICULATE ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/O BART	D-41

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-65	1990 PARTICULATE ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/BART	D-41
D-66	PREDICTED ONE-HOUR CONCENTRATIONS OF CARBON MONOXIDE	D-42
D-67	PREDICTED EIGHT-HOUR CONCENTRATIONS OF CARBON MONOXIDE	D-42
D-68	PREDICTED ONE-HOUR CONCENTRATIONS OF NITROGEN OXIDES	D-42
D-69	PREDICTED ONE-HOUR CONCENTRATIONS OF HYDROCARBONS	D-42
D-70	PREDICTED 24-HOUR CONCENTRATIONS OF PARTICULATES	D-42
D-71	PREDICTED ONE-HOUR CONCENTRATIONS OF SULPHUR DIOXIDE	D-42
D-72	DEFINITION OF SELECTED LOCATIONS FOR DETERMINATION OF AIR QUALITY	D-42
D-73	SELECTED LOCATIONS FOR DETERMINATION OF PREDICTED AIR QUALITY LEVELS	D-42
D-74	EMISSION INVENTORY FOR SIX SCENARIOS	D-46
D-75	SUMMARY OF TOTAL EMISSIONS AND APPROXIMATE CONTRIBUTION TO TOTAL AIRPORT VICINITY EMISSIONS BY SOURCE	D-46
D-76	SUMMARY OF AIRPORT RELATED VMT	D-47

LIST OF EXHIBITS

Exhibit	Title	Following Page
E-1	SANITARY WASTE FLOWS	E-6
E-2	NORMALIZED SANITARY WASTE FLOWS	E-6
E-3	CHARACTERISTICS OF INDUSTRIAL WASTE-WATERS	E-8
E-4	STORM RUNOFF ESTIMATES	E-8
E-5	SEWERAGE UTILITIES PLAN	E-9
E-6	SANITARY SEWAGE TREATMENT PLANTS	E-10
E-7	TREATMENT FLOW DIAGRAM	E-10
E-8	SANITARY TREATMENT PLANT DESIGN CRI-TERIA	E-10
E-9	DRAINAGE UTILITIES PLAN	E-10
E-10	VIOLATION CITATION FORM	E-14
E-11	INDUSTRIAL WASTEWATER TREATMENT PRO-POSED COLLECTION SYSTEM SEPTEMBER 1973	E-14
E-12	GENERAL INDUSTRIAL WASTE TREATMENT FLOW DIAGRAM	E-15
E-13	EFFLUENT DISCHARGE REQUIREMENTS	E-15
F-1	LOCATION AND MAGNITUDE OF EARTHQUAKES IN THE BAY AREA (1934-1965)	F-4
F-2	ENGINEERING PROPERTIES OF BAY MUDS	F-5
F-3	AIRPORT SUPERIMPOSED ON 1930 TOPOGRAPHY	F-7
F-4	BEHAVIOR OF SOIL AND FILL MATERIALS UNDER LOADINGS	F-9
F-5	AREAS OF TSUNAMI RUN UP	F-12

LIST OF EXHIBITS

Exhibit	Title	Following Page
G-1	PREDICTED AVIATION FUEL CONSUMPTION	G-9
G-2	NATURAL GAS CONSUMPTION AT SFIA	G-12
G-3	ELECTRICAL POWER CONSUMPTION AT SFIA	G-14
G-4	VEHICLE GASOLINE CONSUMPTION	G-15
G-5	SUMMARY OF ENERGY IMPACT	G-17
G-6	SOLID WASTES AT SFIA	G-21
G-7	PACIFIC FLYWAY	G-25
G-8	SAN FRANCISCO BAY IN SAN FRANCISCO INTERNATIONAL AIRPORT AREA	G-25
G-9	RESPONSE OF CALIFORNIA DEPARTMENT OF FISH AND GAME	G-26
G-10	RESPONSE OF UNITED STATES DEPARTMENT OF THE INTERIOR	G-26
G-11	SAN FRANCISCO BAY NORTHERN SAN MATEO COUNTY	G-28
G-12	RESPONSE OF DEPARTMENT OF PARKS AND RECREATION	G-30
H-1	AIR POLLUTION EMISSIONS	H-9
H-2	NOISE IMPACT SUMMARY	H-11
H-3	WATER QUALITY IMPACT	H-13
H-4	SOLID WASTE IMPACT	H-15

LIST OF EXHIBITS

Exhibit	Title	Following Page
H-5	ENERGY IMPACT	H-17
H-6	GROUND ACCESS IMPACTS	H-20
H-7	AIRPORT-RELATED EMPLOYMENT--1975	H-29
H-8	PROJECTIONS OF AIRPORT-RELATED EMPLOYMENT	H-32
H-9	AIRPORT-RELATED PAYROLL	H-34
H-10	AIRPORT INDUCED EXPENDITURE EFFECT	H-36
H-11	SUMMARY OF BENEFIT AND COST INDICATORS	H-43

APPENDIX D

AIR QUALITY

APPENDIX D

AIR QUALITY

With the constantly increasing air traffic throughout the last two decades it has become increasingly obvious that airport operations contribute significant sources of visible air pollution, and that they generally impact upon the quality of air within airport environs. Thus, investigations have been conducted during recent years focusing upon the nature and control of airport-related air pollution emissions.

The Air Quality Act of 1967 and the Clean Air Amendments of 1970 gave impetus to a series of studies related to aircraft emission control technology, aircraft exhaust measurements, and the impact of aircraft emissions on air quality.[1/] Furthermore, the U.S. Environmental Protection Agency (EPA) has enacted emission standards for aircraft. The emission standards for new and in-use gas turbine engines, new and in-use piston engines, and new and in-use auxiliary power units have already taken effect and will extend through 1981.

The production of pollutants from airport sources, including aircraft, ground access vehicles, airport service vehicles, stationary sources

---

1/ See selected references at the end of this appendix for a complete description of these studies.

(maintenance operations, fuel storage, heating plants, etc.) and construction operations, is a widely acknowledged fact. A study entitled "Nature and Control of Aircraft Engine Exhaust Emission," by the Northern Research and Engineering Corporation for the Department of Health, Education and Welfare (HEW) found the density of airport related emissions and resulting pollutant concentrations are comparable to emission densities and concentrations of the same pollutants from other sources in adjacent communities. (1) It was further concluded in the HEW study that the principal impact of airport-related emissions is local in nature. Thus, airport-related emissions are typically considered in terms of their effect on the air quality within the airport and adjacent communities.

1. INTRODUCTION

As part of the RASS, the Bay Area Air Pollution Control District performed a study in 1971 (Aviation Effect On Air Quality) to predict air quality conditions at several Bay Area airports, including SFIA. This study indicated that in 1972, aircraft contributed approximately 1.5 percent of all air contaminant emissions in the Bay region, and that by 1985, this contribution would increase to approximately 6.0 percent because of increased air travel together with decreased emissions from automotive sources.

The proposed terminal expansion at SFIA in and of itself will not cause increased air pollution in the Bay region or in the environs of SFIA. Aircraft and ground access traffic which are the major contributors of air pollution at the airport, will be the same in future years whether or not the

proposed terminal complex expansion is implemented. However, the operational efficiency of the airport is highly dependent upon the degree to which the facility is developed to accommodate the inevitable increases in traffic. The resulting efficiency, expressed in terms of both aircraft and motor vehicle movements and delays, will in turn affect air quality.

With the above in mind, the San Francisco Airports Commission, undertook this study in December, 1974 to provide a more recent investigation of the effect of SFIA operations on air quality and to specifically address the question of the probable impact, if any, of the proposed terminal expansion on air quality. The investigation included air quality monitoring in the vicinity of SFIA, an emission inventory and dispersion modeling.

(1) Purpose and Scope

The air quality analysis was performed in order to provide an assessment of the effects of the SFIA expansion program and associated airport operations upon air quality at the airport and surrounding environs. The results of the analysis formed part of the basis for the overall evaluation of the potential significant environmental effects of the proposed airport development.

The analysis involved the examination of existing and future air quality by estimating air pollutants associated with airport-related activities. These activities include:

- Aircraft operations
- Ground access traffic (on and off airport)
- Service vehicle operations
- Stationary sources
  - Hangars and maintenance operations
  - Heating units
  - Storage and transfer of fuel

The estimates of air quality were used to ultimately determine compliance with State of California and National Ambient Air Quality Standards (NAAQS) at the airport and surrounding environs.

Six scenarios were selected which formed the scope of the air quality evaluation. These scenarios are presented in the table below:

Scenario	Time Frame	Airport Configuration	Annual Air Passenger Demand (Millions) 1/
1	1974	Existing	16.2
2	1982	No Further Development	24.4
3	1982	Proposed Development	24.4
4	1990	No Further Development	31.0
5	1990	Proposed Development Without BART Link	31.0
6	1990	Proposed Development With BART Link	31.0

The operational data utilized in the analysis of each of the six scenarios are those presented in Appendix A, Airport Facility Requirements and Appendix C, Ground Access. These data are described in subsequent sections of this appendix.

1/ The air passenger demand in this context is given in terms of total on and off passengers.

(2) Approach

The air quality evaluation was accomplished by two basic approaches. These included:

- Emission inventory of all significant airport-related and non-airport (near vicinity) activities which generate air pollution
- Atmospheric dispersion modeling, which gives consideration to the spatial distribution of emissions developed in the inventory, and the effects of meteorological conditions on resultant pollutant concentrations

The results of the emission inventory were used to assess the contribution to the total emission load on the region of airport-related activities, while the results of the dispersion modeling provided an indication of compliance with State of California and NAAQS. In addition, both techniques provided a relative measure of the effects on air quality of the six scenarios previously described. The emission inventory and dispersion modeling techniques are described in detail in Section 4 of this appendix, entitled Evaluation Methodology.

The pollutants considered in the air quality evaluation included the following:

- Carbon monoxide
- Total hydrocarbons

- Oxides of nitrogen
- Sulphur dioxide
- Particulate matter
- Oxidant

Emission factors for the various airport and non-airport sources were based on EPA data as reported in AP-42, Compilation of Emission Factors (2). Data requirements for the modeling effort included detailed descriptions of aircraft and ground support vehicle activity, airport stationary sources, and mobile source activity for the airport and its environs.[1/]

The analysis also included the assessment of the variable "vehicle miles traveled" (VMT) for each of the six scenarios. The estimated VMT for each scenario is an indication of the average round trip distance which ground access traffic would accrue (on and off airport) traveling to and from the airport. The importance of VMT in the analysis is to demonstrate compliance with the State of California "Transportation Control Strategies" and "Air Quality Implementation Plans" for critical regions (3). These strategies call for minimization of VMT for these critical regions.

1/ During the analysis phase, the effect of a one year postponement of automotive emission control standards was investigated and found to effect resulting emissions in 1982 and 1990 by less than two percent. Therefore, the effect of the one year postponement was not included in the analysis.

2. LOCAL SETTING

The object of this section is to provide information for assessing the air pollution impacts of the airport development alternatives. Specifically, the regional level of air pollution is examined, and the situation close to the airport is discussed in some detail. Data which describe the regional meteorological conditions are also presented.

The quality of the air in a given region is determined primarily by two factors. These are:

- The kinds and amounts of contaminants introduced into the atmosphere by anthroprogenic and natural sources in the region
- The effective volume of air available for dilution, and the residence time of the pollutants in the effective volume. These factors are determined by the region wide climatological features

To a lesser extent, contaminants generated in other regions throughout the world contribute to the ambient pollution level by means of the complex atmospheric transport processes. To properly assess the impacts of further development of the airport, the quality of the ambient air and the factors which affect it must be defined or described.

(1) Ambient Air Quality

San Francisco International Airport (SFIA) is one of many complex sources of air pollution in the Bay area. The nine county

Bay area has been identified as an Intra-state Air Quality Control Region (AQCR) as defined by the U.S. EPA (4) and by the California Air Resources Board (5). Generally, the total daily emissions of pollutants into the air of the Bay Area have been significantly reduced from the historic high levels during the late 1960's. An exception to this trend has been some of those pollutants which are developed by fuel combustion: nitrogen oxides, sulphur dioxides and particulate matter. Exhibit D-1, on the following page, shows the historical data and trends in average daily emission developed by the Bay Area Air Pollution Control District (BAAPCD).

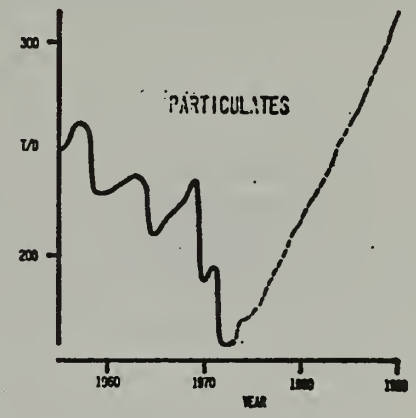
The San Francisco Bay Intra-state Air Quality Control Region is operating under the California Transportation Control Plan (3) which was promulgated by the U.S. EPA on November 11, 1973. This plan sets forth an implementation plan for achieving and maintaining the NAAQS for photochemical oxidant as well as the standards for carbon monoxide, nitrogen oxides, and non-methane hydrocarbons. A summary of the impacts of the elements of the transportation control strategy for the San Francisco Bay Region in 1977 are shown in Exhibit D-2, following Exhibit D-1. It is noted that the EPA in formulating control strategies for the San Francisco Region adopted use of national control strategies for aircraft rather than imposing stricter controls for the region.

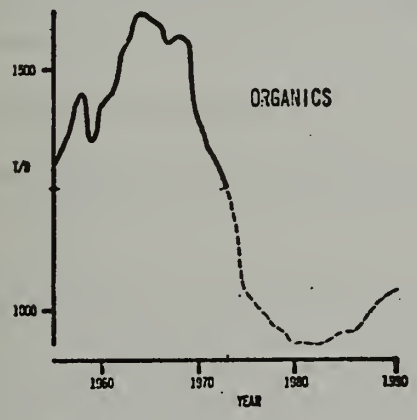
EXHIBIT D-1
San Francisco International Airport
HISTORY AND TRENDS IN
AMBIENT AIR QUALITY

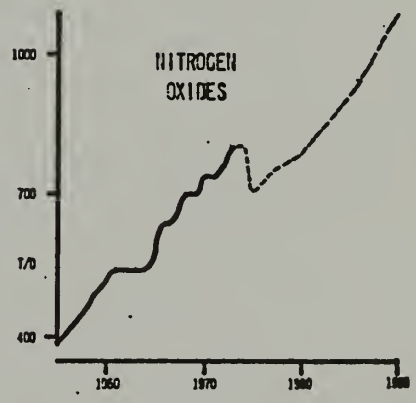
The dotted portions of the curves below indicate projections into the future.

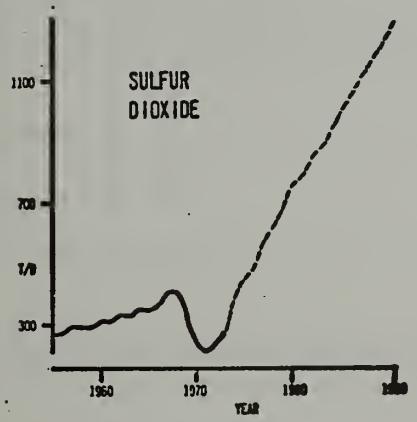
The projected increases in particulate and sulfur dioxide emissions are because of the greater fuel oil usage mentioned on p. 10. Organic emissions continue to decline as automotive control requirements become increasingly stringent. Nitrogen oxide emissions continue to climb with energy consumption even though there will be some reduction because of motor vehicle controls.

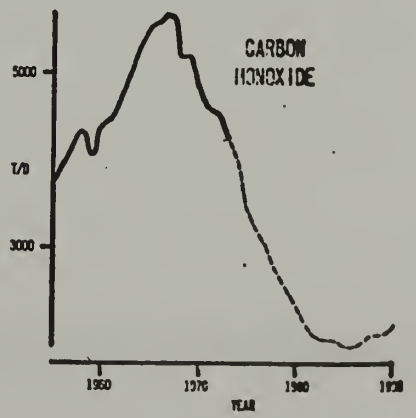
Projections into the future assume that fuel oil will be available in sufficient quantity to meet our demands. If energy shortages develope, the PARTICULATE, NITROGEN OXIDES, and SULFUR DIOXIDE curves may not increase as steeply as shown in this report.











Source: Source Inventory of Air Pollutant Emission in the San Francisco Bay Area (7)

EXHIBIT D-2
San Francisco International Airport
SUMMARY OF IMPACT OF CONTROL STRATEGIES IN SAN FRANCISCO BAY REGION IN 1977

Source of pollution and control measures	Emissions and Reductions/day of reactive hydrocarbons	Percent Reduction Per Measure
Stationary source emissions in 1977 without control strategy-	225	----------
Expected reductions:		
1. Gasoline marketing vapor recovery---------	-138	45.8
2. Surface coating, dry cleaning, and degreasing controls----------	- 37	12.3
Stationary source emissions remaining----------	50	----------
Mobile source emissions in 1977 without proposed control strategy----------	201	----------
Expected reductions:		
1. Reductions from only EPA-promulgated VMT control strategies assuming an 11 percent VMT reduction.[1]----------	- 14	4.7
2. Light-duty motor vehicle inspection and maintenance and catalytic converter retrofit----	- 33	11.0
3. Motorcycle emissions regulation----------	- 6	2.0
4. VMT reductions necessary from additional control strategies to be implemented in 1977----	- 73	24.2
Mobile emissions remaining ----------	75	----------
Total emissions remaining----------	125	----------
Allowable emissions to attain standards.[2]----------	125	----------

1 Using optimistic assumptions and estimates of both EPA and local VMT reduction measures, a total reduction of 32 percent VMT, or 41 tons/day could occur.

2 Based on linear rollback model.

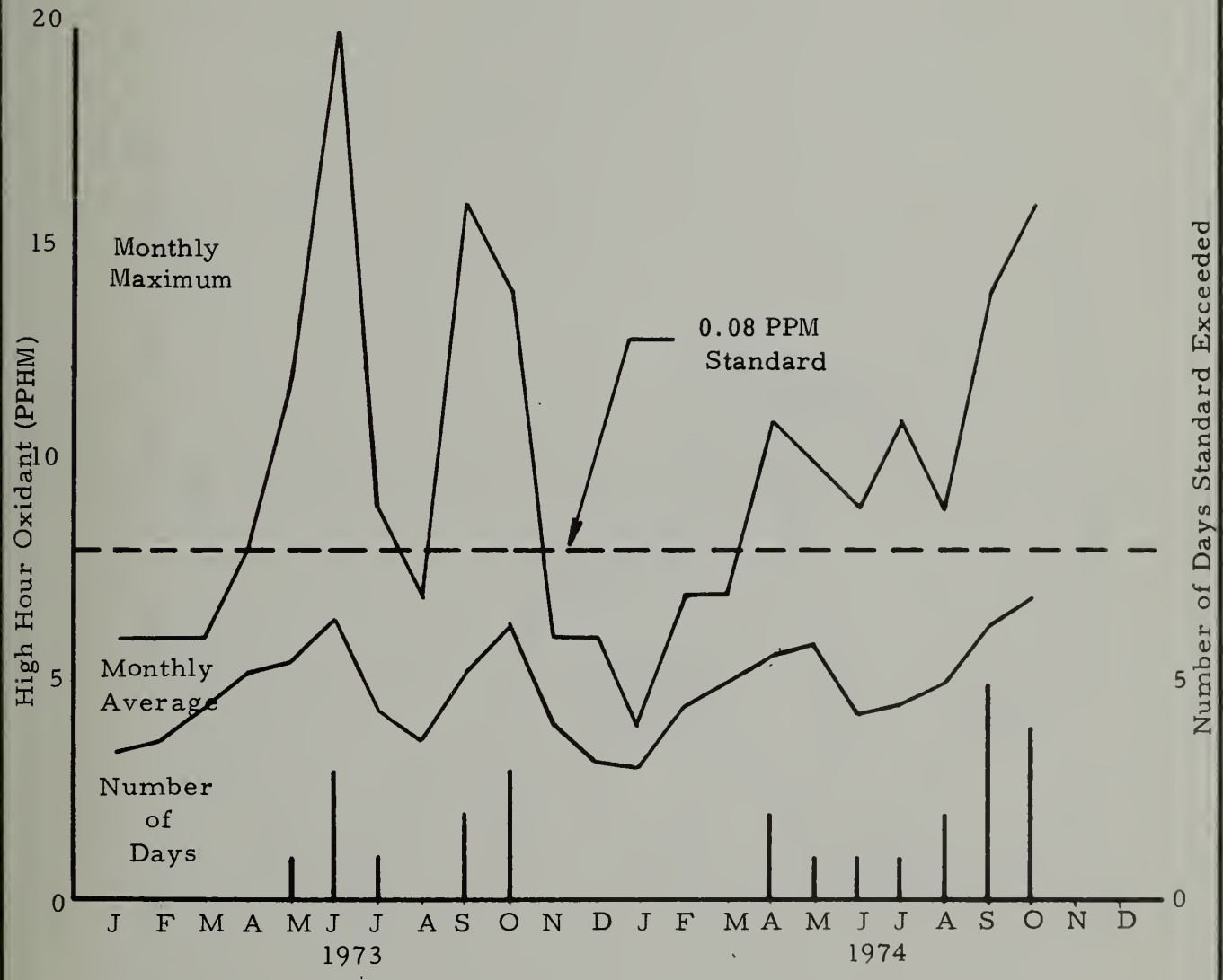
Source: Fed. Reg. 38, 217, 31244
Nov. 12, 1973.

The BAAPCD maintains a monitoring station at Burlingame, California which is about two miles southwest of SFIA. The station records data on carbon monoxide, oxidant, sulphur dioxide, and suspended particulate matter. Exhibit D-3, on the following page, shows the monthly average and maximum high hour concentration of oxidant for the years 1973 and 1974.[1/] This exhibit also shows the number of days per month on which the NAAQS for oxidant was exceeded during the period. Exhibit D-4, following Exhibit D-3, shows the average and maximum high hour concentrations of carbon monoxide measured at the Burlingame station. Exhibits D-5 and D-6, which follow Exhibit D-4, show the average concentration data record for sulphur dioxide and the monthly geometric mean for suspended particulate matter.

The BAAPCD does not monitor oxides of nitrogen at Burlingame so that monthly data for this pollutant is not available from that station. The Redwood City, California BAAPCD station, which is 10 miles south and east of SFIA, does record oxides of nitrogen, and this data record of 1973 and 1974 is given as Exhibit D-7. Hydrocarbons which are mainly of concern as a reactive element in the production of photochemical oxidants, are not measured by the BAAPCD network since the BAAPCD has measuring capability for oxidant directly.

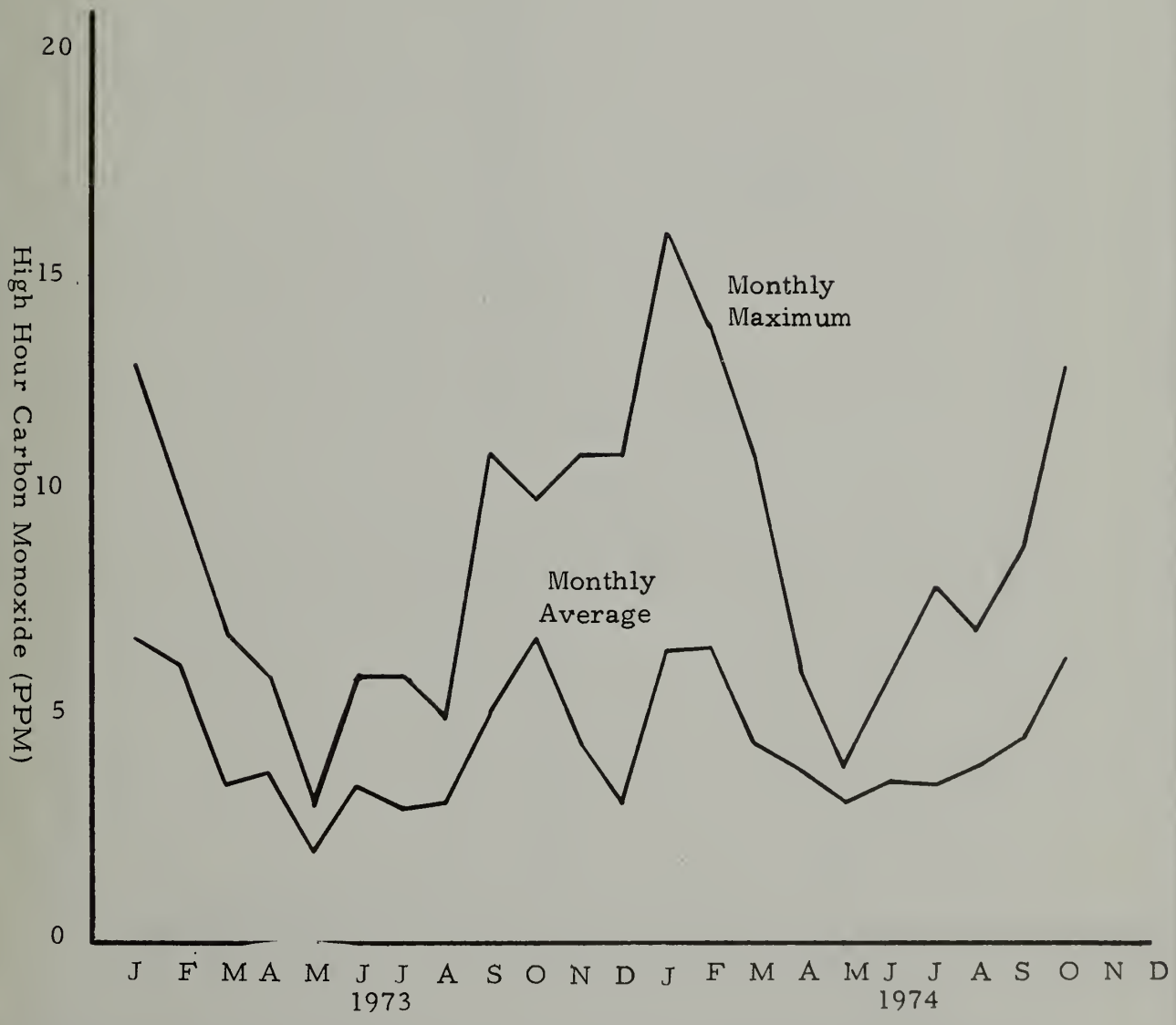
1/ Data is published monthly in Reference (8)

EXHIBIT D-3
San Francisco International Airport
HIGH HOUR OXIDANT
CONCENTRATIONS AT BURLINGAME



Source: Landrum and Brown

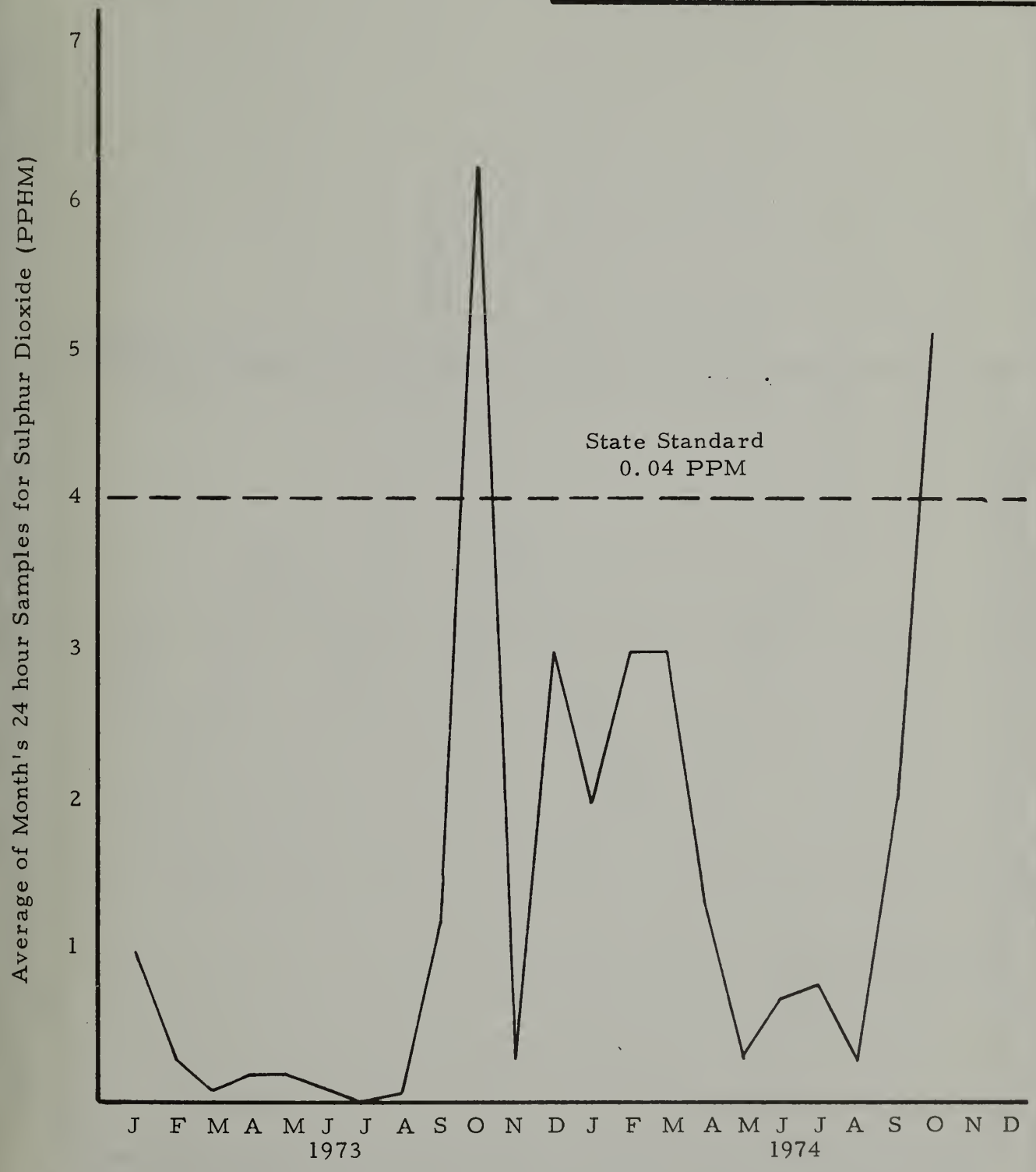
EXHIBIT D-4
San Francisco International Airport
MONTHLY AVERAGE HIGH HOUR
CARBON MONOXIDE CONCENTRATIONS
AT BURLINGAME



Federal AAQS = 35 ppm 1 hour average
9 ppm 8 hour average

Source: Landrum and Brown

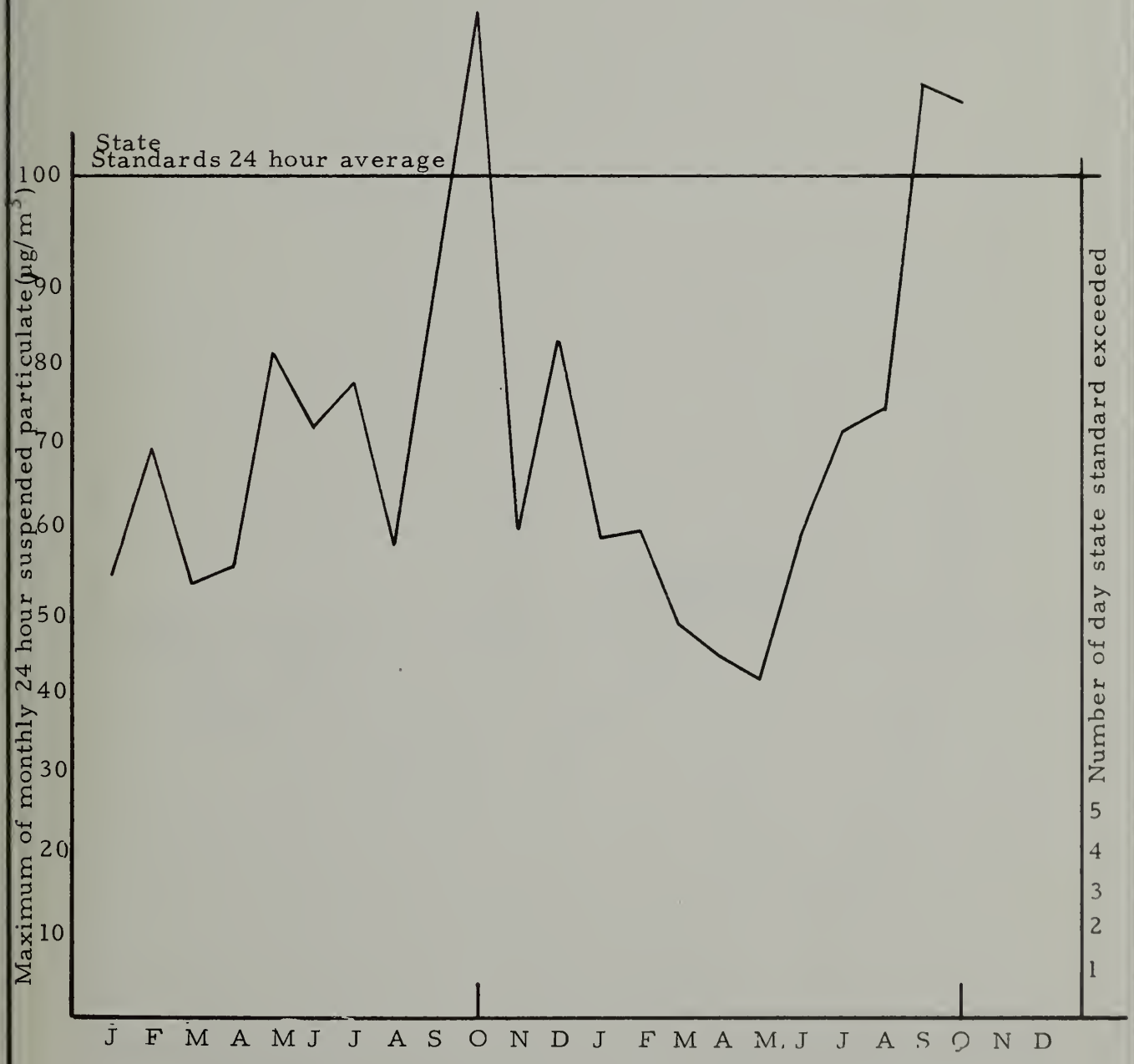
EXHIBIT D-5
San Francisco International Airport
AVERAGE OF MONTH's 24 HOUR
SULPHUR DIOXIDE MEASUREMENTS
AT BURLINGAME



Federal Standard 24 hr. Average = 0.14 PPM (Parasosaline Method)
State Standard 24 hr. Average = 0.04 PPM (Conductimetric Method)

Source: Reference (8)

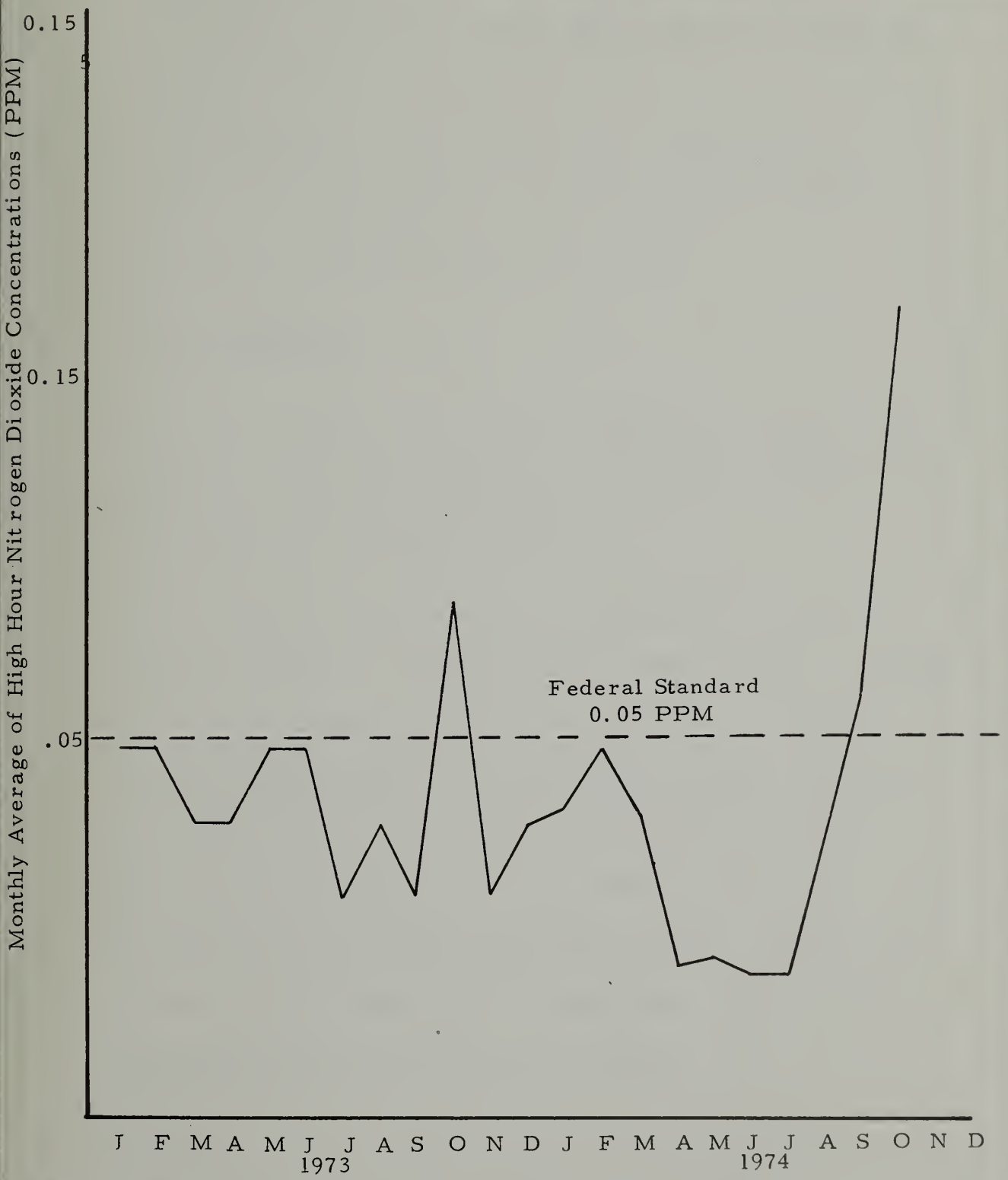
EXHIBIT D-6
San Francisco International Airport
MAXIMUM OF MONTH'S 24 HOUR
SUSPENDED PARTICULATE
MEASUREMENTS AT BURLINGAME



Federal Standards Annual Geometric Mean: 75 $\mu g/m^3$
24 hour average 260 $\mu g/m^3$

Source: Reference (8)

EXHIBIT D-7
San Francisco International Airport
MONTHLY AVERAGE OF HIGH HOUR
NITROGEN DIOXIDE MEASUREMENTS
AT REDWOOD CITY


0.15
0.15
.05
Monthly Average of High Hour Nitrogen Dioxide Concentrations (PPM)
Federal Standard
0.05 PPM
J F M A M J J A S O N D J F M A M J J A S O N D
1973
1974

Federal Standard 0.05 PPM (Colorimetric Method)
California Standard 0.25 PPM (Saltzman Method)

These data records show the extent and frequency of air pollution problems in the vicinity of SFIA, especially in areas of high residential land use. Only in the case of oxidants are there frequent and substantial deviations from the standards. Suspended particulate matter standards were exceeded twice, only in October, 1971 and again in October, 1974, at the Burlingame station. The standards for carbon monoxide and sulphur dioxide have not been exceeded during the two year period reported.

(2) Climatology

The subject of region wide climatology was reviewed in detail in 1971 in the Aviation Effects on Air Quality (9). This report forms the basis for the following discussion.

The nine counties of the San Francisco Bay Area together form an air basin as defined by state and federal agencies. Pollutants are dispersed and transported within such a basin so that their control requires common action on an areawide basis. The shared problem does not, however, imply a homogeneity or uniformity of meteorological conditions. Weather differences throughout the Bay Area are startlingly large, particularly in summer. From the coast inland some forty miles to the Livermore Valley, afternoon surface temperatures may increase by 40 to 50 degrees F. San Francisco's

typical WNW summer sea breeze may be manifested as ESE at San Rafael, SSW at Richmond, WSW at Fairfield, NNW at San Jose, and NNE at Mountain View.

This variability results from the complex physiography of the Bay Area. The Pacific Ocean to the west, with its cold California current just offshore, provides a source of cold surface temperatures; in comparison, the Sacramento-San Joaquin Valley to the east is very warm in summer and relatively cold in winter. The topography of the Bay Area establishes many valley and slope airflow regimes, varying widely within short distances. Built-up urban areas and open rural land furnish additional variables affecting stability and airflow. The frequent temperature inversions over the area limit the available dilution air and intensify the many mesoscale differences in airflow and stability beneath them.

1. Inversion Climatology

A primary factor in air quality is the mixing depth, i.e., the vertical dimension available for dilution of contaminant sources near the ground. For aircraft in flight, the mixing depth would also determine the altitude below which their emissions would contribute to ground level concentrations. The frequent occurrence over the Bay Area of temperature inversions limits this mixing depth and consequently limits the availability of air for dilution. A temperature inversion may be described as a layer or layers of warmer air over cooler air.

Several types of temperature inversions typical of summer are formed by subsidence, the heating of downward

moving air in the anti-cyclone over the Western Pacific. The surface inversions typical of winter are formed by radiation as air is cooled in contact with the earth's cold surface at night. Both types of inversion mechanism may operate at any time of the year. At times, surface inversions formed by radiational cooling may reinforce the subsidence inversion aloft, particularly in fall and winter. The thick, strong inversion resulting in this case is, of course, especially effective in trapping pollutants.

The only routine measurement of vertical temperature structure over the Bay Area is that taken by the National Weather Service twice daily, at 0400 (4 a.m.) and 1600 (4 p.m.) at Oakland International Airport.

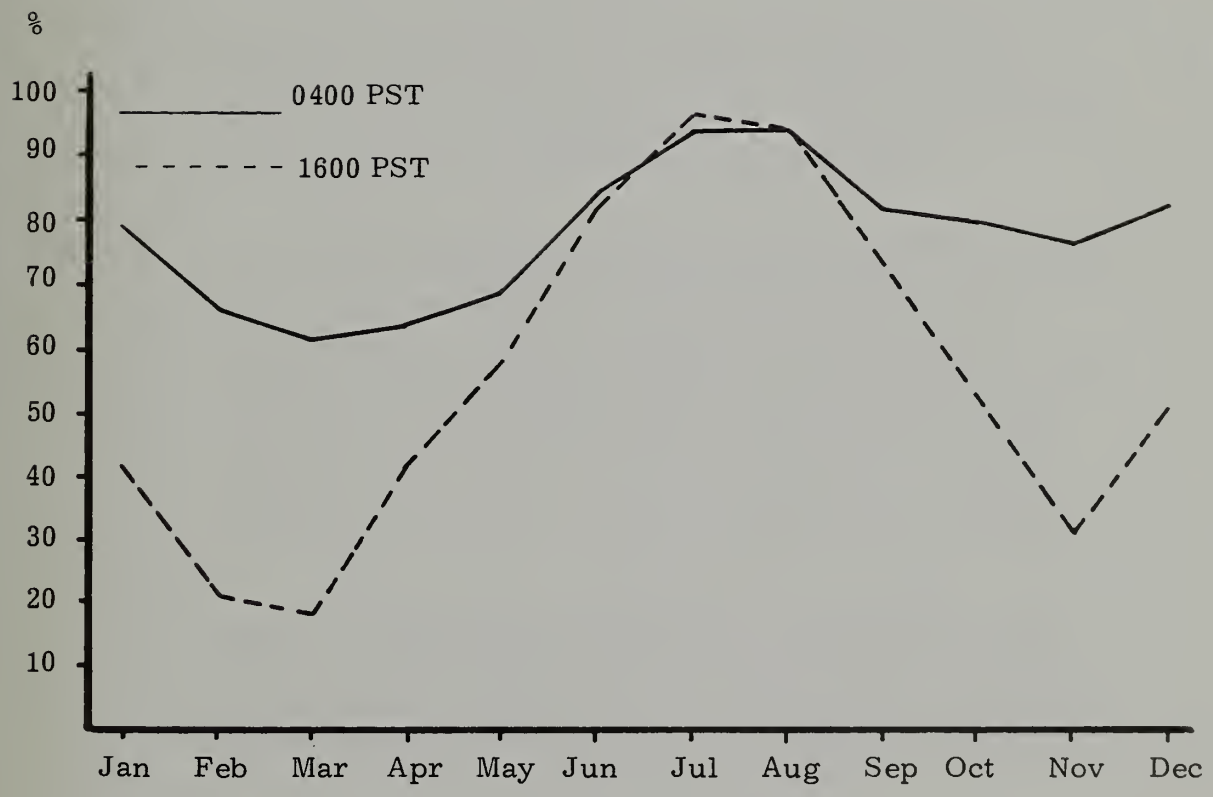
There is wide seasonal variation in the type of inversion found, and there is wide variation over the course of the day in inversion characteristics. Moreover, the terrain of the Bay Area may induce significant variations from point to point, and wave mechanisms may cause considerable fluctuation in the inversion base.

To monitor these inversions, the BAAPCD has made daily analyses of the Oakland radiosonde data.[1/] For each day from January 1, 1957 through December 31, 1967, the 0400 and 1600 Oakland soundings from the surface to 850 millibars (approximately 5000 feet) were categorized according to the base of the lowest temperature inversion (if any). Class intervals of 500 feet were used to determine the distribution of inversion bases by month.

For a 2500 foot mixing depth derived from our terrain as a clean air requirement, the cumulative occurrences have been graphed as percentage frequencies based on the 11 years of data (1957-67) as shown in Exhibit D-8, on the following page. The afternoon data show that restrictive inversions persist over 90 percent of the time in July and August and generally well over 50 percent of the time in May, June, September and October. From November through April, however, restrictive conditions persist less than 50 percent (except for a slightly anomalous 52.1 percent in December). For a given month, the year-to-year variation in summer is negligible, but in winter some wide fluctuations are apparent, particularly for February.

1/ Additional analysis has been performed by others, refer to reference (10), (11), and (12).

EXHIBIT D-8
San Francisco International Airport
PERCENTAGE FREQUENCY OF
INVERSIONS AT 3500 FEET OR LESS



Source: Reference (9)

2. Airflow Regimes

In a region of complex topography and frequent inversions, patterns of airflow can be quite complicated. At a given point (e.g., an airport) along a shoreline or in a valley, the wind direction may be exceptionally steady and relatively predictable in terms of daily and seasonal pattern. Within several miles, however, another point in a differently oriented valley or along an opposite shore may manifest steady winds of a very different direction. An intermediate point, influenced by several valleys or shore configurations, may show great variability. Thus, it is unsafe to generalize wind patterns in the Bay Area from only a few observation points. Streamlines drawn to an extensive network of wind data points provide the best representation of Bay Area conditions.

Such a study was made of the Bay Area by Clarence Smalley of the (then) U.S. Weather Bureau as part of a special Civil Defense program (13). Since its preparation in March 1957, this study has become a standard reference on the local meso-meteorology of the Bay Area.

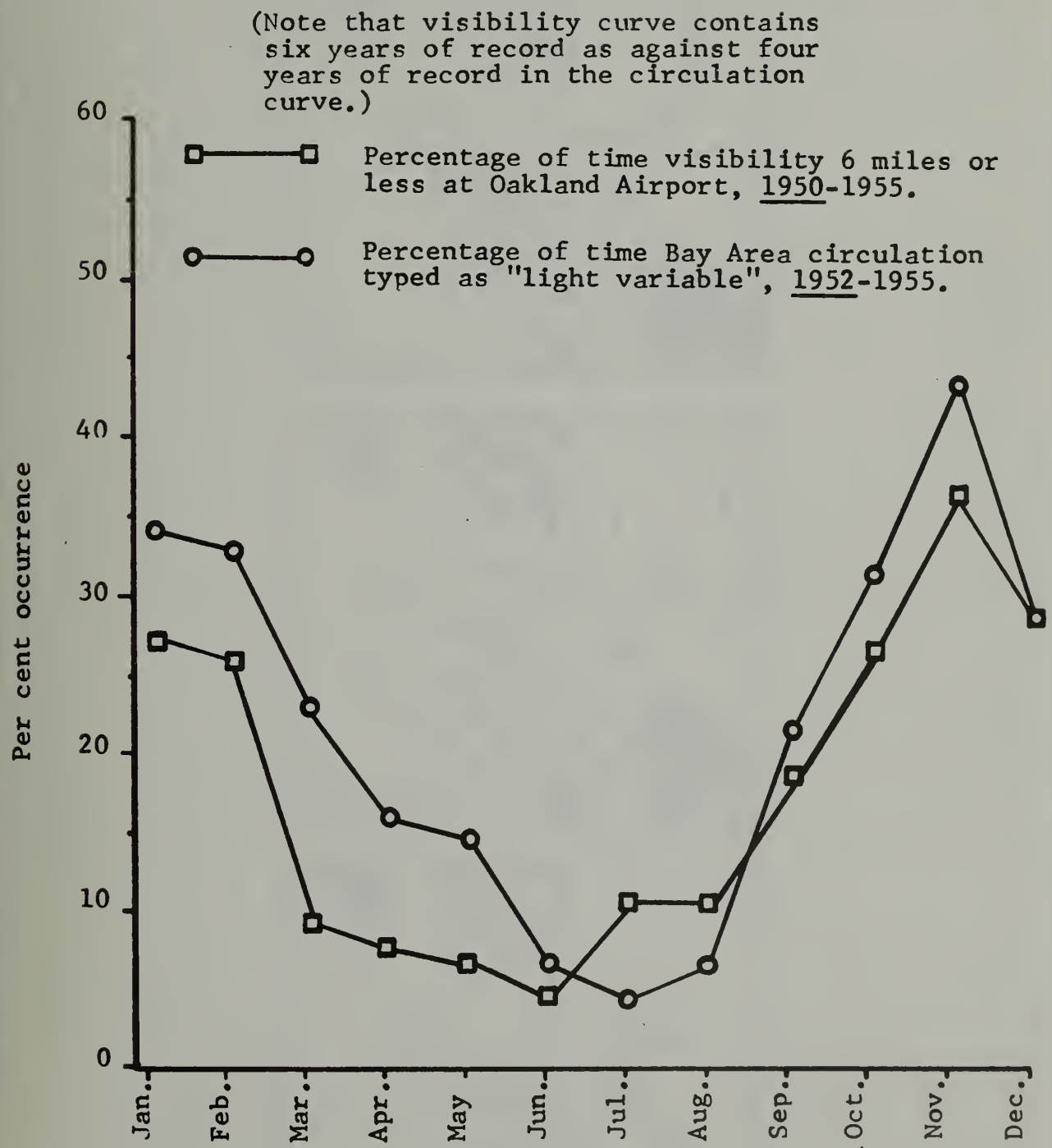
For this study, a meso-analysis was made every six hours from 1952 through 1955. From the 1464 maps, based on 33 cooperative stations, 40 airflow patterns were distinguished. Simple patterns were associated with unstable air and strong gradients; complex patterns, more affected by topographic features, were associated with inversion conditions and weaker gradients. A separate "light variable" class showed an annual occurrence of 22 percent reaching as high as 44 percent for November.

The importance of the "light variable" class on air quality is indicated by Exhibit D-9, following this page. The frequency of occurrence of "light variable" airflow in the Bay Area by month follows very closely the impairment of visibility at Oakland Airport to 6 miles or less, giving a strong indication of particulate pollution.

The actual airflow patterns (other than "light variable") are given in Exhibits D-10 through D-17, following this page, for eight basic compass points. In response to physiography, normal airflow across the area is radically distorted for many regimes, particularly those in which high air pollution levels are likely to occur.

EXHIBIT D-9
San Francisco International Airport

VISIBILITY AND
CIRCULATION PATTERNS

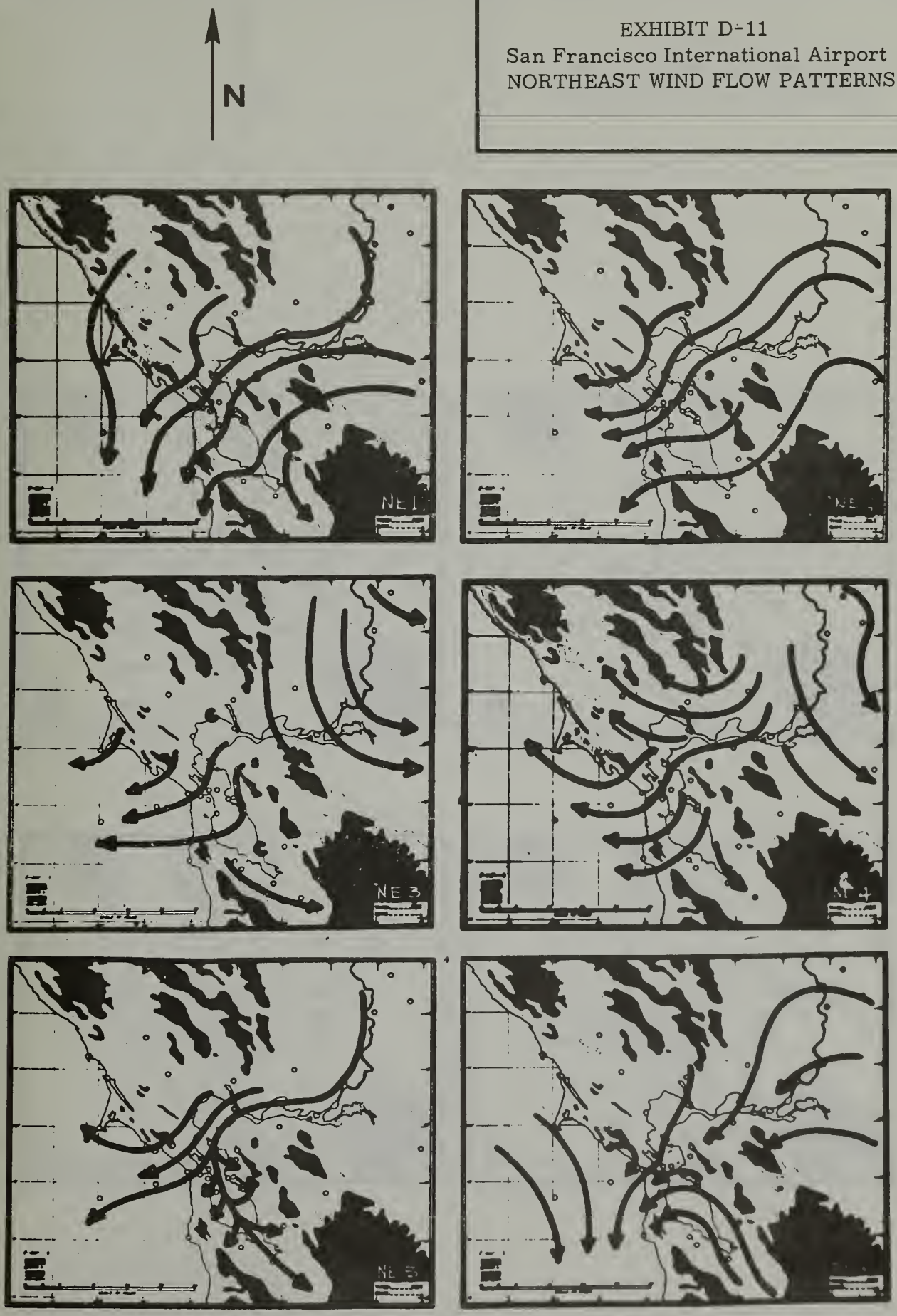


Source: Reference (9)

EXHIBIT D-10
San Francisco International Airport
NORTH WIND FLOW PATTERNS

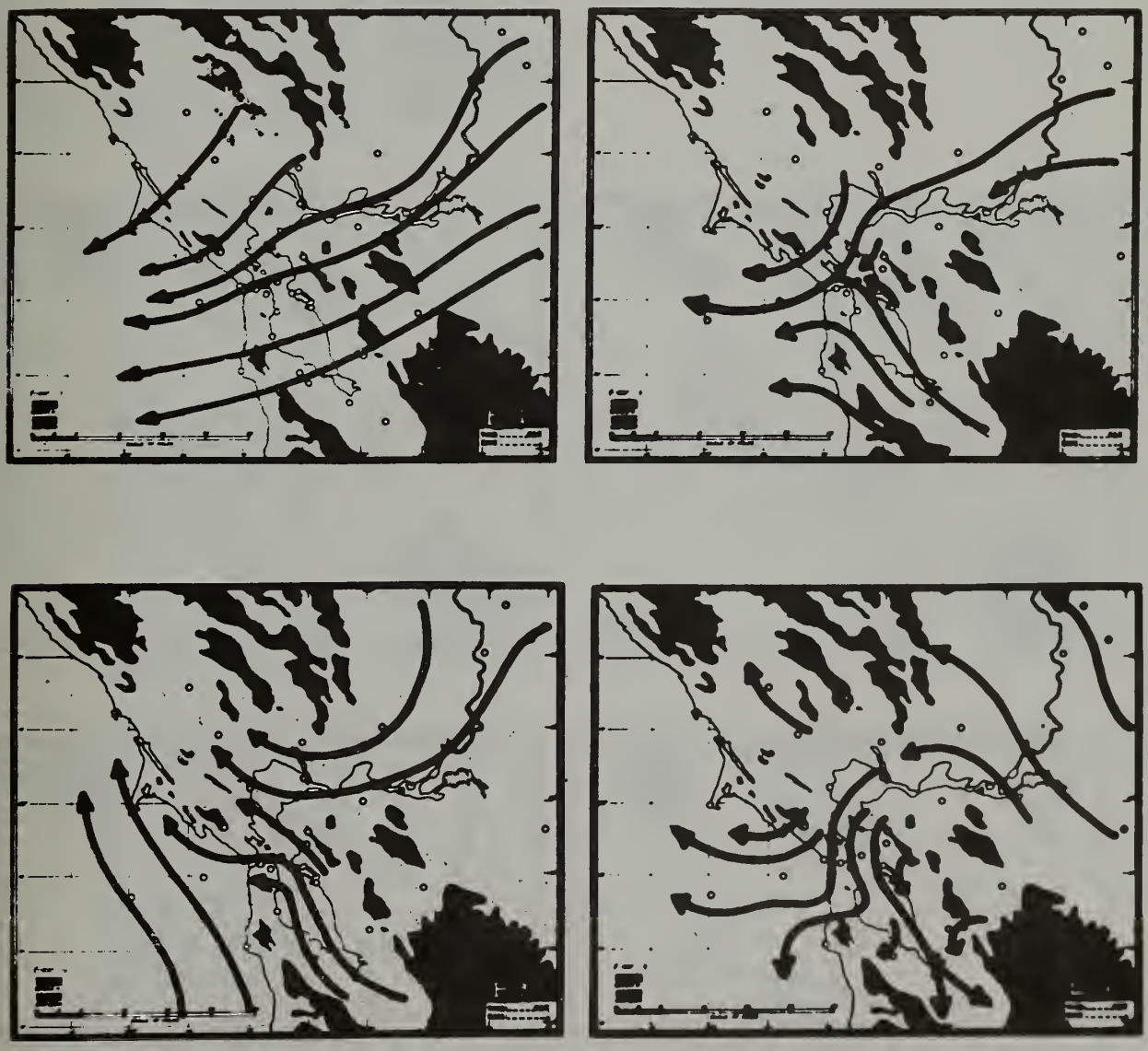
Source: Reference (9)

EXHIBIT D-11
San Francisco International Airport
NORTHEAST WIND FLOW PATTERNS



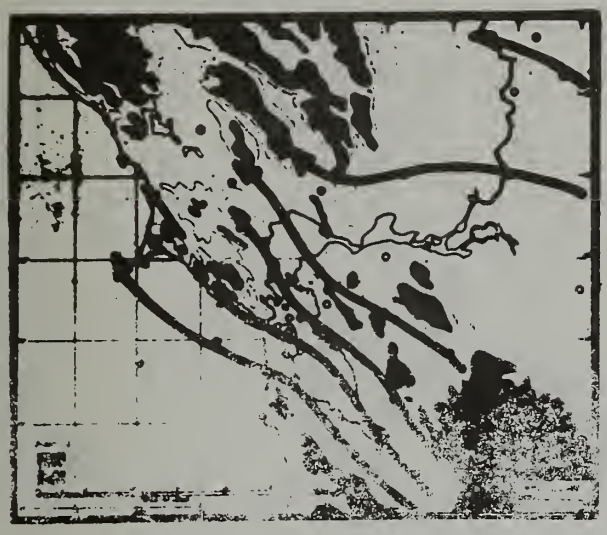
Source: Reference (9)

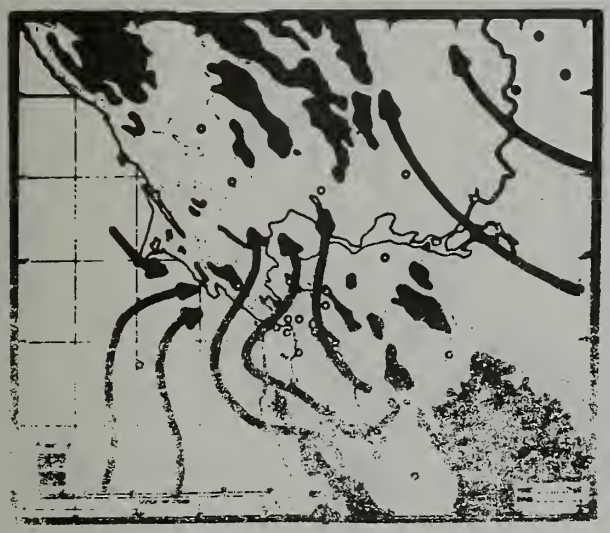
EXHIBIT D-12
San Francisco International Airport
EAST WIND FLOW PATTERNS

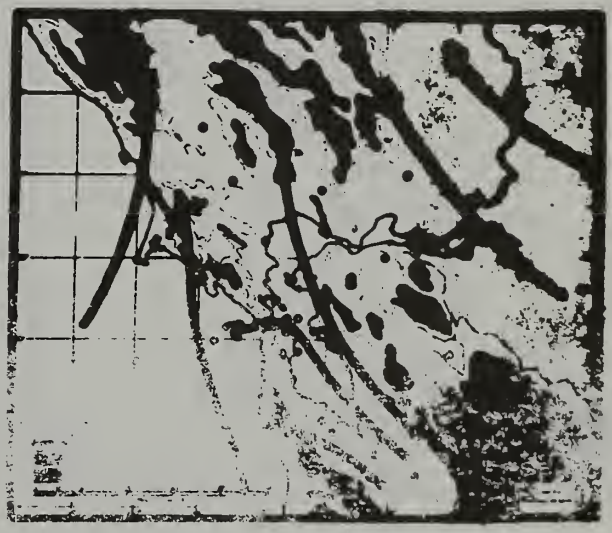


Source: Reference (9)

EXHIBIT D-13
San Francisco International Airport
SOUTHEAST WIND FLOW PATTERNS







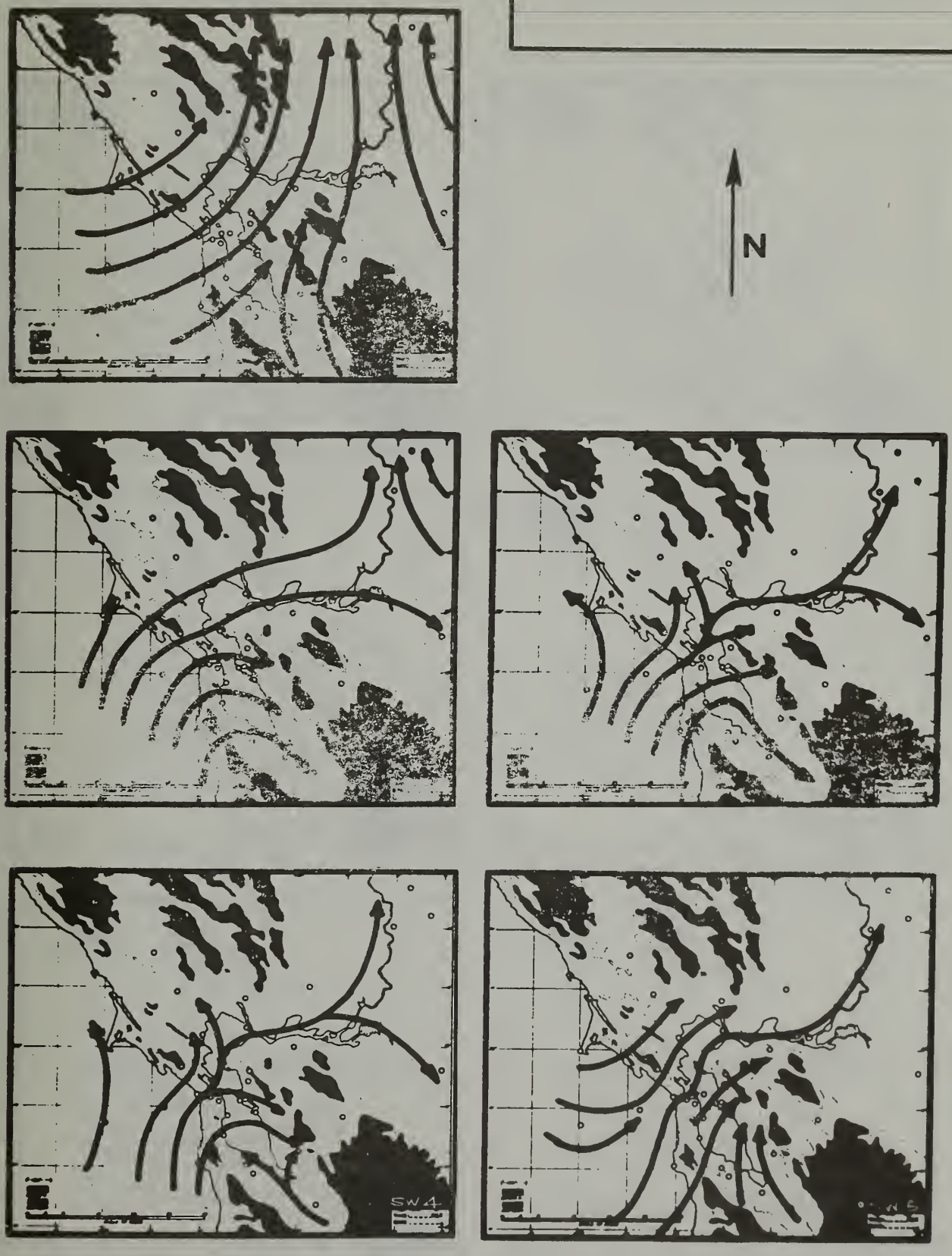
N

Source: Reference (9)

EXHIBIT D-14
San Francisco International Airport
SOUTH WIND FLOW PATTERNS

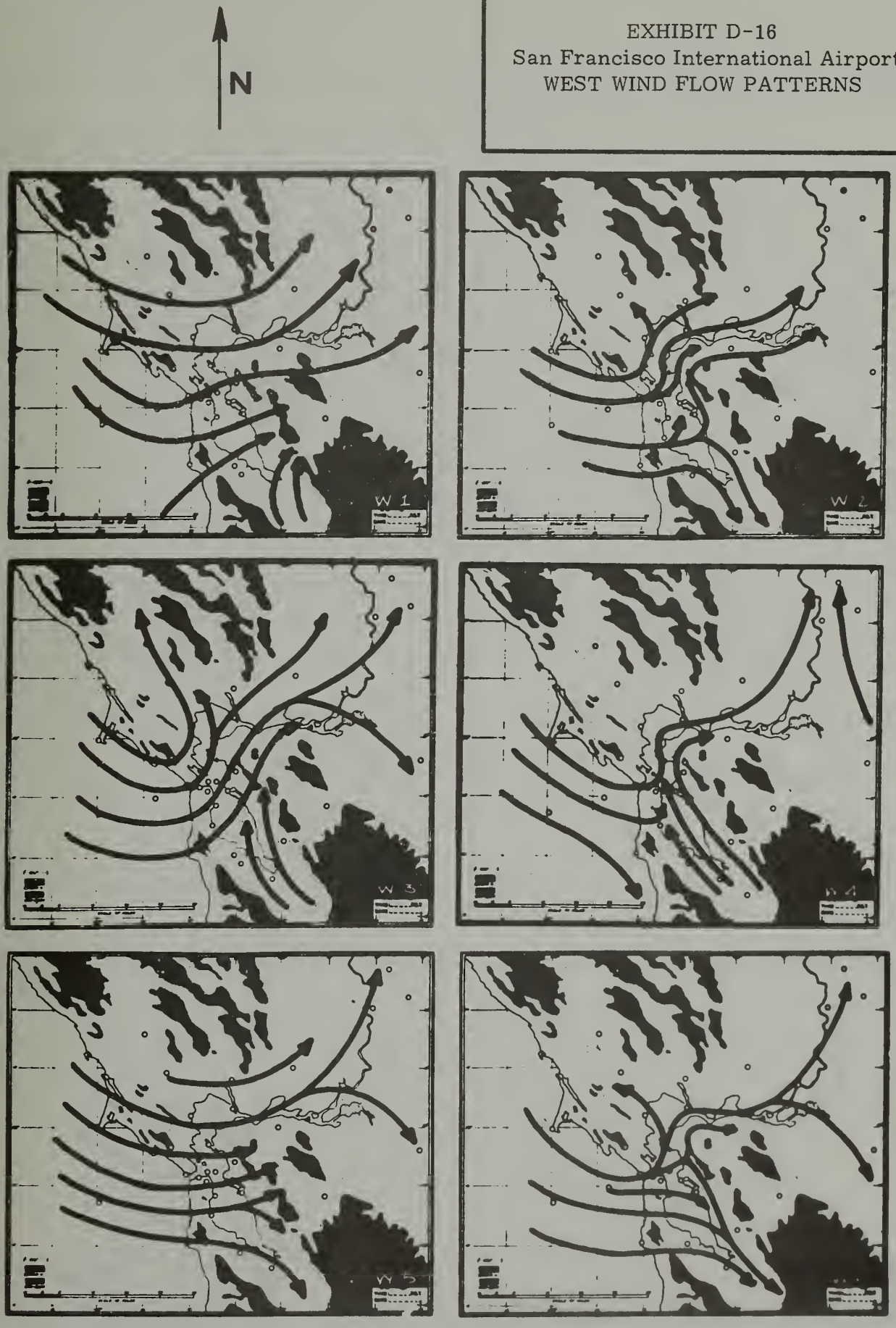
Source: Reference (9)

EXHIBIT D-15
San Francisco International Airport
SOUTHWEST WIND FLOW PATTERNS



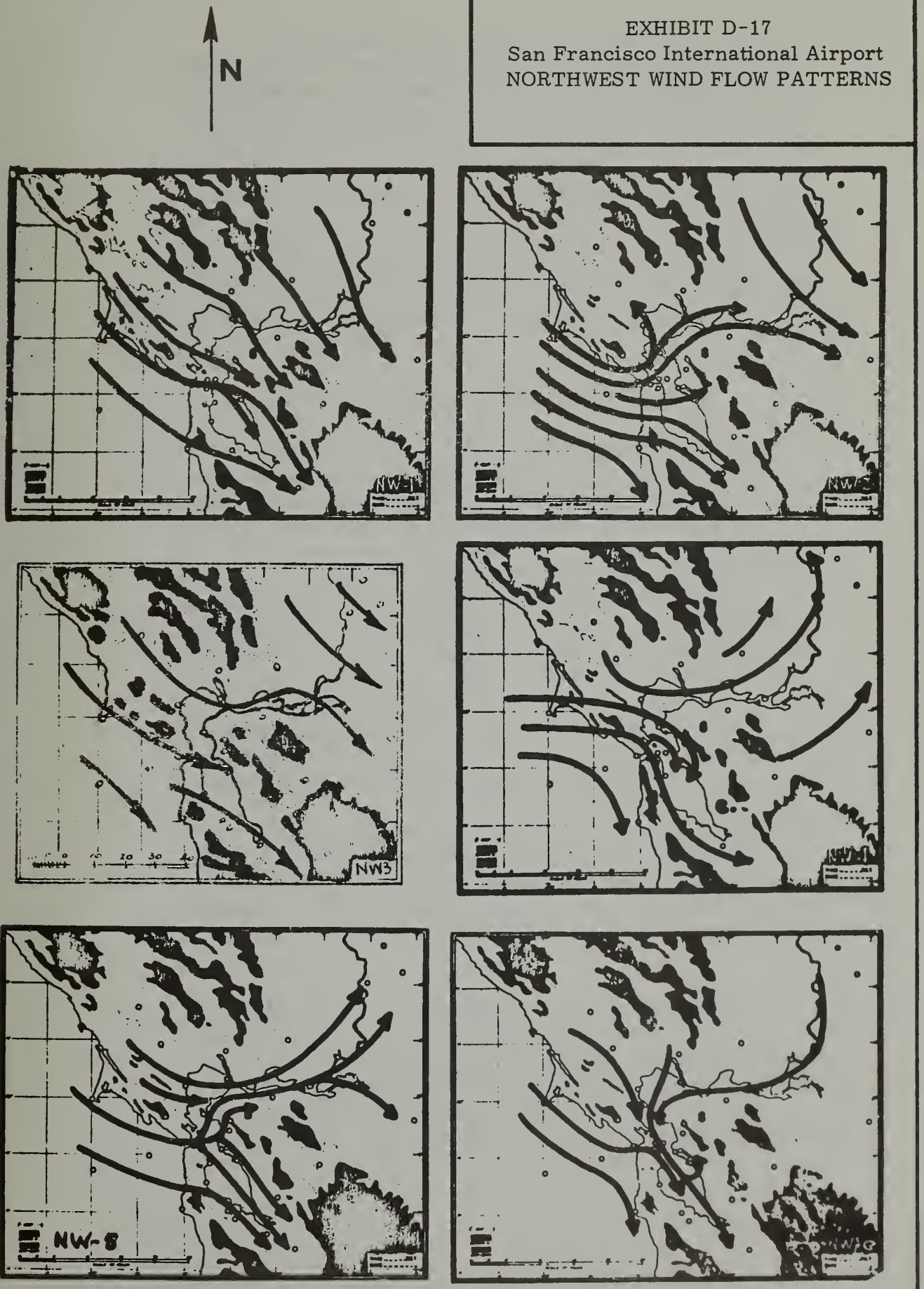
Source: Reference (9)

EXHIBIT D-16
San Francisco International Airport
WEST WIND FLOW PATTERNS



Source: Reference (9)

EXHIBIT D-17
San Francisco International Airport
NORTHWEST WIND FLOW PATTERNS



Source: Reference (9)

The distortion in wind flow results in major surface wind streams following the lines of least resistance, which are in most cases the sea level portions of the area. Encountering obstacles in the terrain, the air streams may divide and turn. For example, very common westerly types have a major airflow axis across San Francisco which splits against the East Bay hills, with one stream flowing southeast into the Santa Clara Valley, the other flowing northward into the North Bay Area. This latter stream then splits again, with one stream flowing eastward through the Carquinez Straits and the other flowing in an eddy curl from the southeast into the northern Marin County and Petaluma valley area (Exhibit D-15).

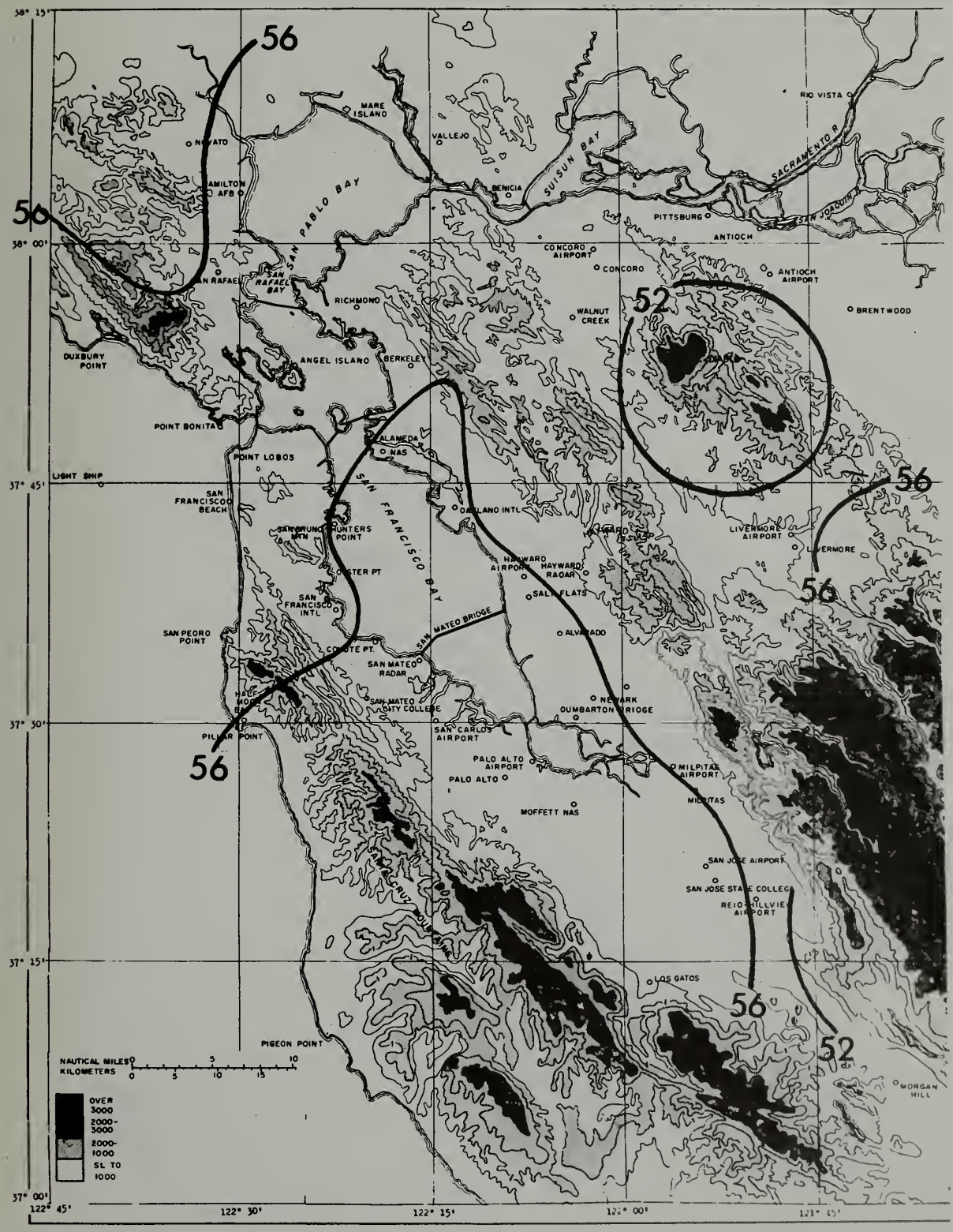
3. Temperature and Precipitation Distribution

Climate is usually classified in terms of annual and seasonal temperature and precipitation values. Even in these formal terms, the San Francisco Bay Area offers many varieties of climate within a few miles. In the ESSA (now NOAA) Environmental Data Service's Climate of California (14) Bay Area isopleths are given for January and July mean maximum and minimum temperatures, and for annual precipitation. These distributions, based on a 1931-1952 data period, are given here as Exhibits D-18 through D-21, on the following pages. They are based on the limited number of long term recording stations available for climatological purposes, and thus have some serious shortcomings in detail. Their great advantage is adequate length of record for climatological purposes.

They are not adjusted for topographic or urban effects, although both of these factors are extremely important. They do, however, grossly reflect the topography, even in the limited data array. Values for Bay Area stations north of the area mapped by ESSA have been plotted at the top of each chart.

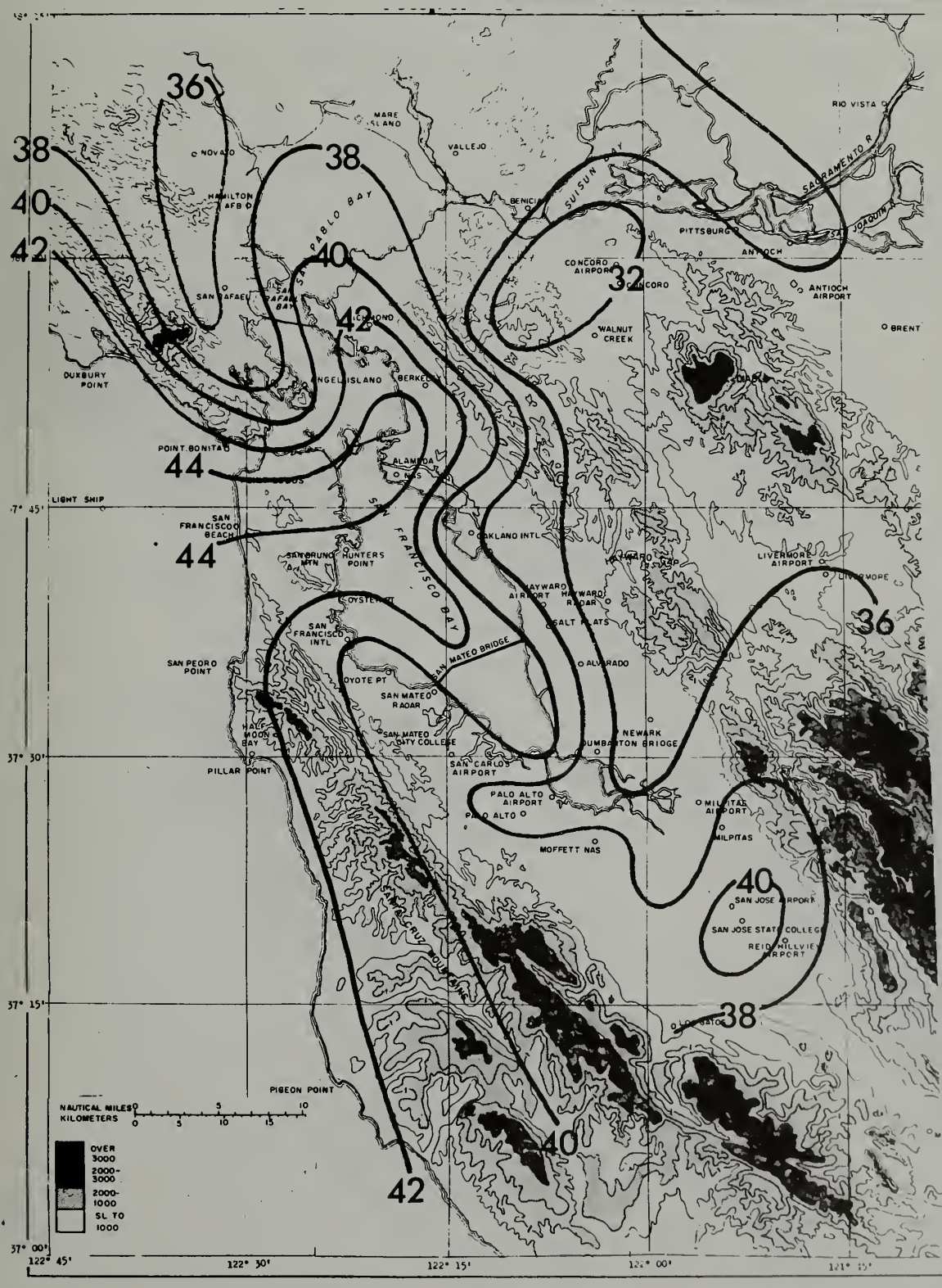
The January maps of mean maximum temperature (Exhibit D-18) and mean minimum temperature (Exhibit D-19) show that variations are significant in the nocturnal minimums, but not in the afternoon maximums. The maximum map shows only a slight decrease of temperature at higher elevations, and thus implies lapse conditions and reasonably good vertical

EXHIBIT D-18
San Francisco International Airport
JANUARY MEAN
MAXIMUM TEMPERATURES



Source: Reference (9)

EXHIBIT D-19
San Francisco International Airport
JANUARY MEAN
MINIMUM TEMPERATURES

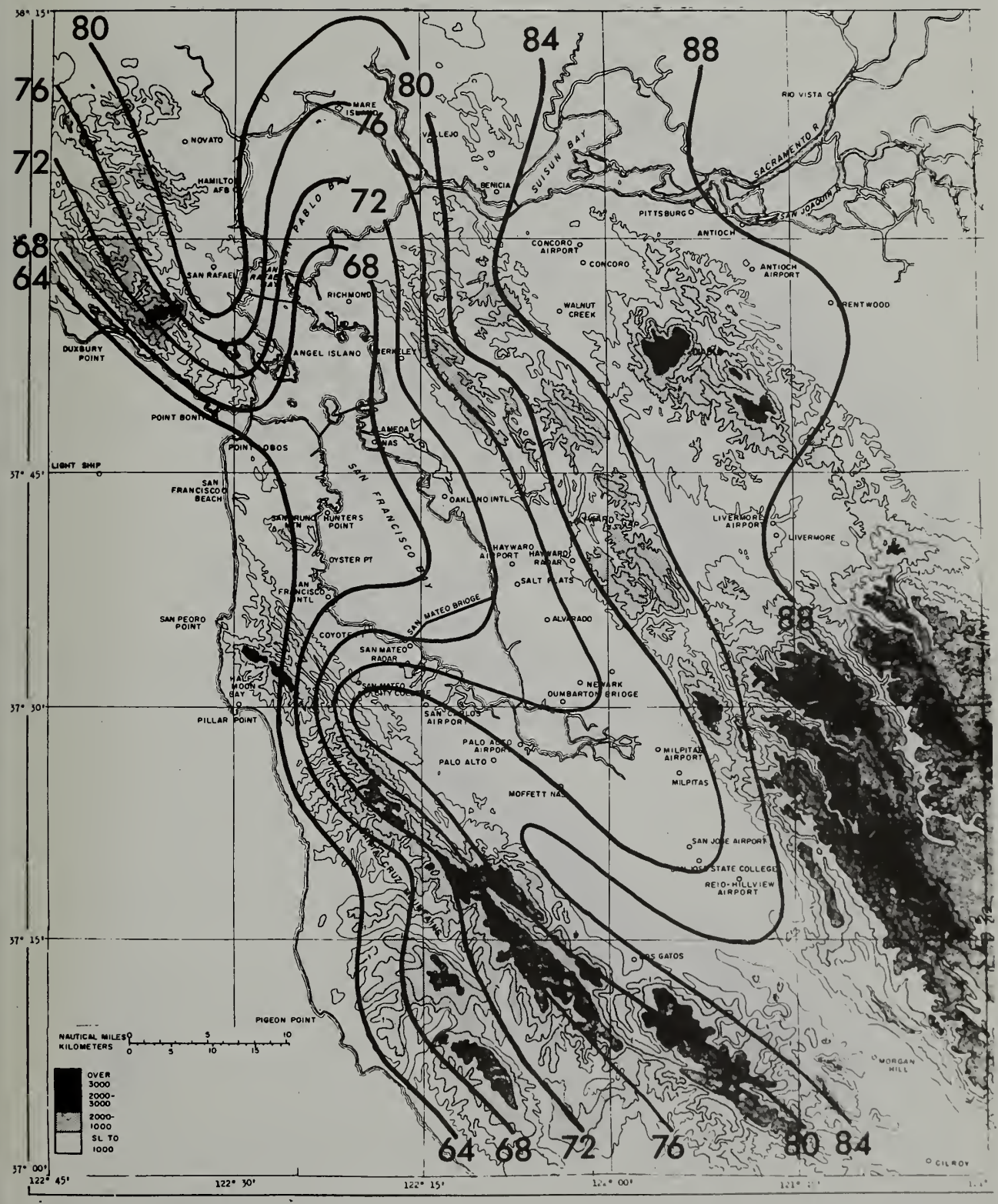


Source: Reference (9)

EXHIBIT D-20

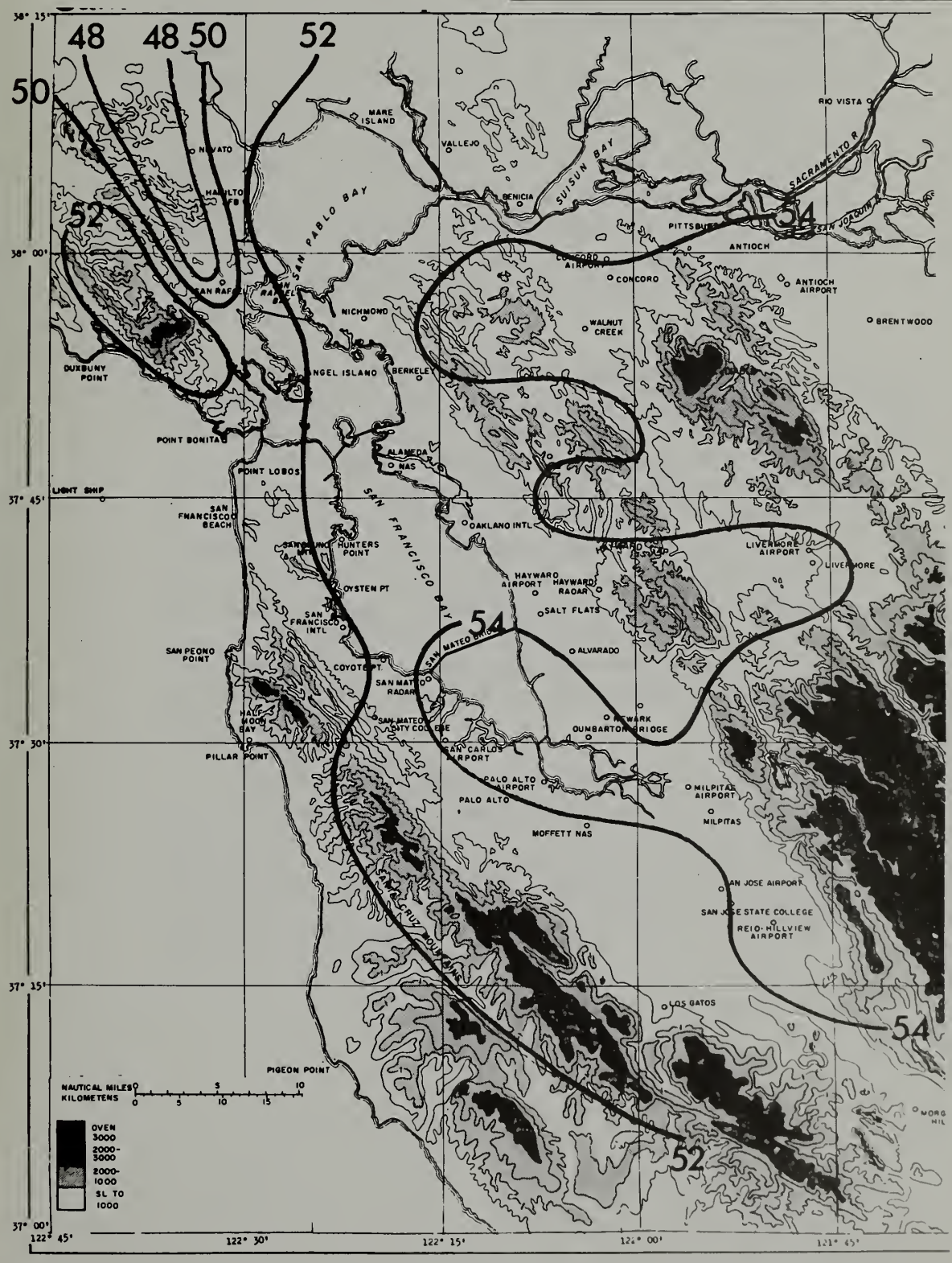
San Francisco International Airport

JULY MEAN MAXIMUM TEMPERATURES



Reference (9)

EXHIBIT D-21
San Francisco International Airport
JULY MEAN MINIMUM TEMPERATURES



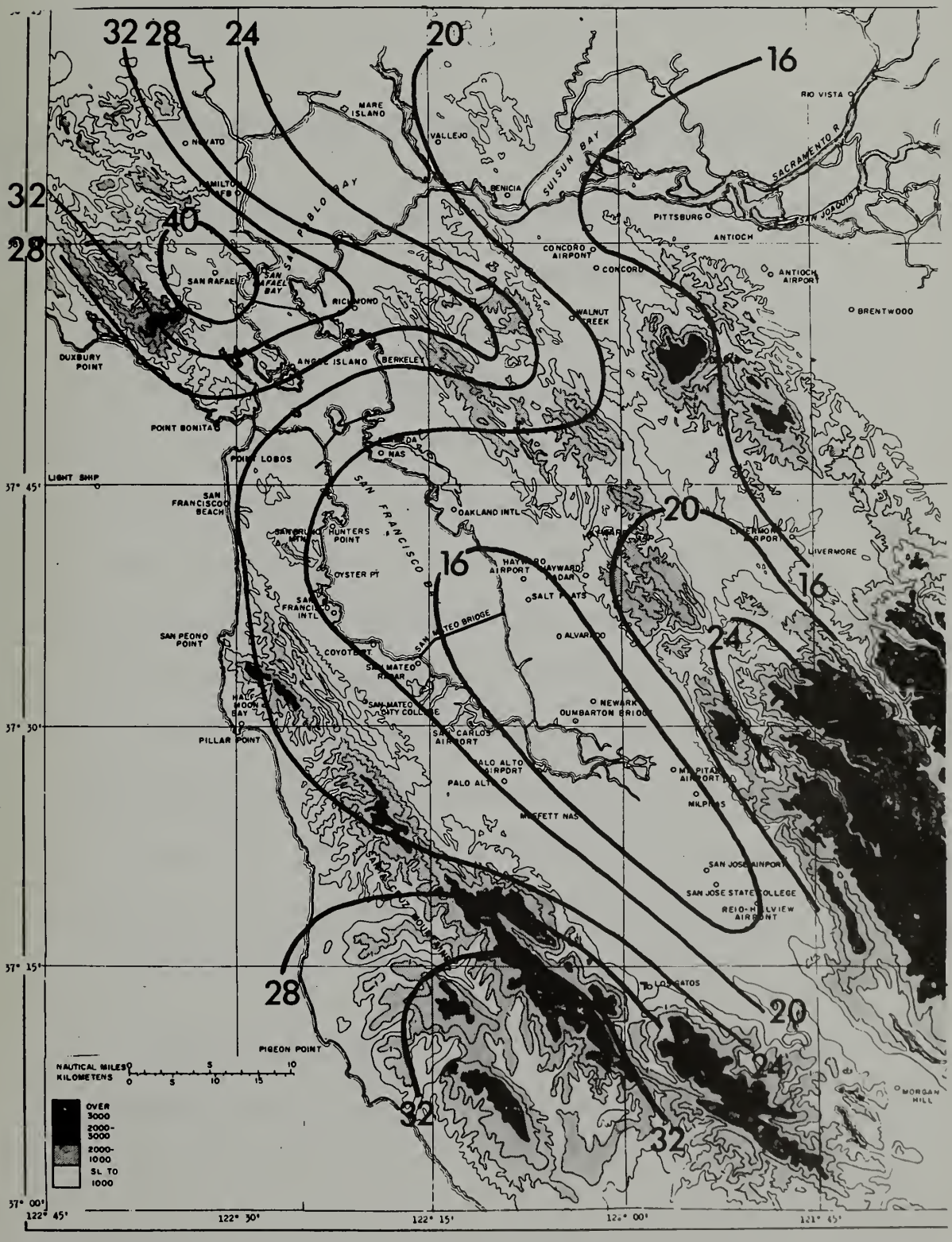
Source: Reference (9)

mixing. The mean minimum temperatures, however, show large differences and strong gradients. Most apparent is the moderating effect of the ocean, with warmer minimums along the coast and penetrating the bay. Coldest temperatures are in the sheltered valleys, implying strong radiation inversions and very limited vertical diffusion. An apparent anomaly of warmer temperatures in the Santa Clara Valley over San Jose is clearly an urban "heat island" effect, most pronounced on winter nights (15). Such heat islands are proportional to structure density, and could be expected to show also over San Francisco and Oakland if the data array were dense enough to reveal them. From an example of one calm winter night, for example, the heat island effect over downtown San Francisco showed a magnitude of 20 degrees F.

The July mean temperature maximums (Exhibit D-20) and minimums (Exhibit D-21) reverse the January relationship in that variations are not significant in the nocturnal minimums, but are very intense in the afternoon maximums. Even in over 20 years of mean July data, the gradient from the coast to the eastern portion of the air basin is 15 degrees F. On extreme days the difference may exceed 50 degrees F. This thermal gradient is one measure of the intense sea breeze flow which may persist throughout the day and night in summer. Since it is usually associated with a strong maritime inversion based near 1000 feet, the related low level stability and diffusion must undergo complex changes in very short distances.

The annual precipitation values as shown in Exhibit D-22, on the following page, also show great difference in short distances. Annual totals exceed 40 inches in the mountains, and are less than 15 inches in the sheltered or "shadowed" valleys. Similar differences in cloudiness and relative humidity may be inferred from the topography, coastal configuration, and airflow.

EXHIBIT D-22
San Francisco International Airport
MEAN ANNUAL TOTAL PRECIPTATION



Reference (9)

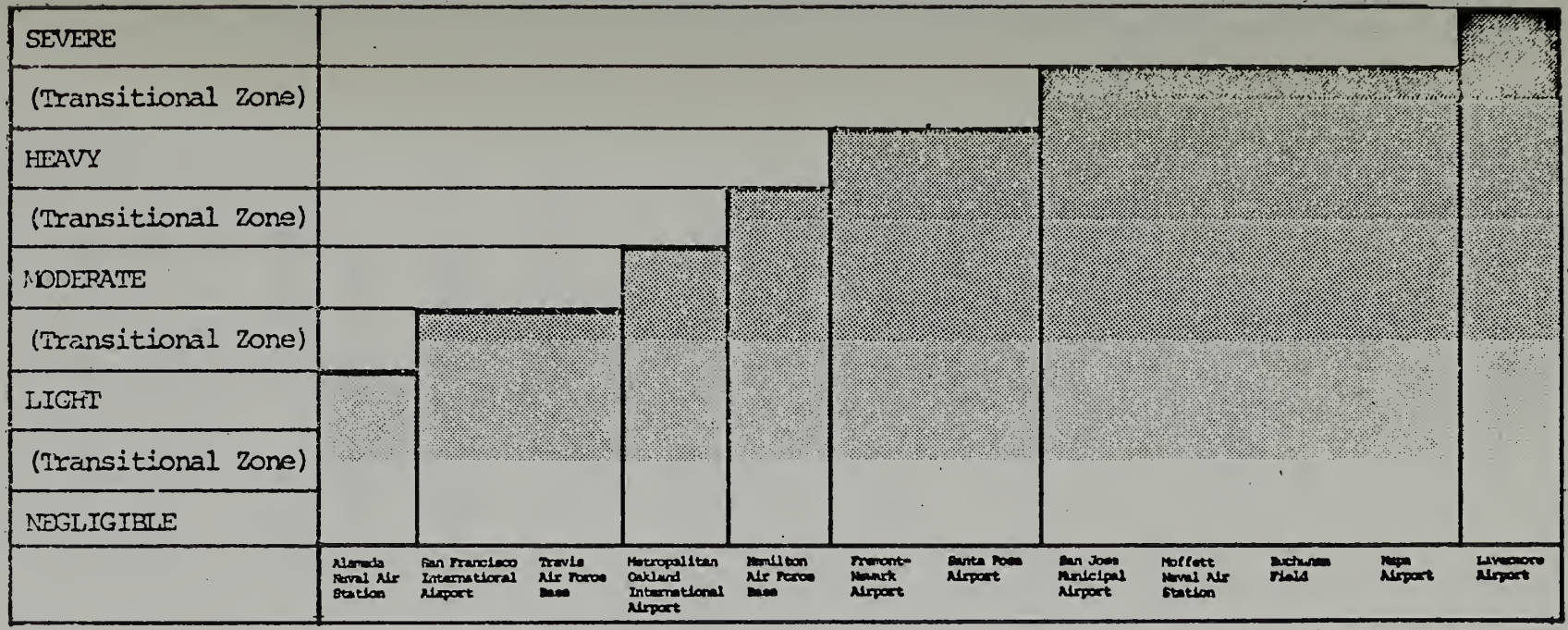
3. AIRPORT ACTIVITIES WHICH AFFECT AIR QUALITY

This section presents an overview of the role of aviation, generally, on regional ambient air quality. In addition, the nature of airport activities which influence local air quality are discussed.

(1) Regional Effects of Transportation on Air Quality

Any airport is a complex configuration of activities which interact with other activities and institutions within and beyond the airport boundary. SFIA, because of its location with respect to the San Francisco metropolitan communities, has probably a more complex relation than most other large airports. Activities at the airport will induce their most significant effects on the adjacent neighboring communities. But since SFIA is just one element, albiet a major one, in the Bay Area transportation system, changes at the airports will have impacts on the other elements of the system, and therefore affect the overall regional air quality. In this context, the relative potential for air pollution of major airports in the Bay Area should be considered. In the RASS study of regional airport development alternatives (15), this comparison was made, and is presented as Exhibit D-23, on the following page.

The absolute amount of aircraft emissions and for motor vehicles have been inventoried by the BAAPCD. The 1973 average



NEGLIGIBLE - Negligible air pollution potential (no contaminant levels will exceed State standards)

LIGHT - Light air pollution potential (State standards for some contaminants will be occasionally exceeded)

MODERATE - Moderate air pollution potential (State standards for all contaminants will occasionally exceeded)

HEAVY - Heavy air pollution potential (State standards for all contaminants will frequently be exceeded)

SEVERE - Severe air pollution potential (State standards for all contaminants will frequently be exceeded by very substantial amounts)

Source: Reference (16)

EXHIBIT D-23
San Francisco International Airport
AIR POLLUTION POTENTIAL FOR
AREAS AROUND MAJOR AIRPORT SITES

annual emissions and relative contribution of transportation sources to the total emission load of the region is shown in Exhibit D-24, following this page. These data show that aircraft emissions, in the regional area, account for only about 3.7 percent of the total particulate emissions and only about one percent of the total organic emissions. For nitrogen oxides, sulphur dioxide and carbon monoxide, air carrier aircraft account for less than one percent of total emissions. Motor vehicles account for more than 90 percent of the carbon monoxide emissions in the region, and about 62 percent of the nitrogen oxides. In addition, motor vehicles generate more than five percent each of the total regional emissions of organics, sulphur dioxide and particulates. These data indicate that transportation sources account for about 20 percent of the total regional emissions. Aircraft operations account for about five percent of the total transportation emissions, while motor vehicles account for the remaining 95 percent.

(2) SFIA Activities Affecting Local Air Quality

The demands imposed on an airport by human wants and needs are responsible for the generation of air pollution at the airport. The amount of pollution generated is determined by the size and kinds of functional activities taking place there. The activities at SFIA which generate pollution can be categorized functionally as follows:

EXHIBIT D-24

San Francisco International Airport

AVERAGE ANNUAL EMISSIONS FROM TRANSPORTATION SECTOR 1973

	Particulate		Organics		Nitrogen Oxide		Sulfur Dioxide		Carbon Monoxide	
	(TPD)	(%)*	(TPD)	(%)*	(TPD)	(%)*	(TPD)	(%)*	(TPD)	(%)*
Aircraft										
Air Carriers	4.1	3.7	12.0	1.0	8.3	1.0	0.9	0.4	23	0.5
General Aviation	0.8	0.5	4.1	0.3	1.4	0.2	---	---	20	0.5
Military	4.3	2.7	7.7	0.6	4.8	0.6	0.6	0.2	19	0.4
Totals	9.2	6.9	12.0	1.9	14.5	1.8	1.5	0.6	62	1.4
Motor Vehicles										
Cars & LT Trucks	31.0	2.0	540.0	4.4	340.0	44.0	8.2	3.3	3,500	83.0
Heavy Trucks	5.4	3.4	44.0	3.6	117.0	16.2	6.2	2.5	331	7.9
Buses	0.5	0.3	0.6	---	17.0	2.3	0.2	0.1	10	0.2
Motor Cycles	0.2	0.1	17.3	1.4	0.3	---	---	---	47	1.2
Totals	37.1	5.8	601.9	9.4	474.3	62.5	14.6	5.9	3,888	92.3

* Percent of total regional average annual emissions.

Source: Reference (9)

- Aircraft operations
- Access vehicle traffic
- Service vehicle traffic
- Stationary source operations

The interplay of these activities is shown schematically on Exhibit D-25, on the following page. In what follows, the manner in which these activities affect the air quality are described.

1. Production of Air Pollutants by Jet Aircraft

The principal pollutants emitted from jet engines are oxides of nitrogen, carbon monoxide, hydrocarbons, and particulates. When expressed as a mass percentage of fuel burned, each pollutant is usually emitted in small amounts varying between 0.1 and 1.0 percent under most operating conditions. Emissions of carbon monoxide and hydrocarbons are especially high during idle and taxi operations, while oxides of nitrogen and particulate emissions are usually greatest during takeoff and landing. Carbon monoxide is the largest constituent by weight. Hydrocarbon, nitrogen oxides and particulates follow in descending order.

A study by the Department of Health, Education and Welfare (HEW) (1), indicates that the weight of pollutants injected into the atmosphere is heavily conditioned by the amount of time spent in taxiing the aircraft around the airport. The concentrations of the various pollutants versus engine power setting are shown in Exhibit D-26, following Exhibit D-25. At idle power settings, the concentrations of carbon monoxide and hydrocarbons are quite high, and reduce rapidly as the power is increased toward the takeoff setting. On the other hand, the production of oxides of nitrogen rises as the power level is increased. The range in values of the concentration level are indicative of several types of jet engines currently in use by the airlines.

An indication of the commercial aircraft air pollution trend, by year, is indicated in Exhibit D-27 following Exhibit D-26. The trend demonstrates the improvements that occurred

EXHIBIT D-25
San Francisco International Airport
SCHEMATIC DESCRIPTION OF DEMANDS
AND SOURCE OF AIR POLLUTION

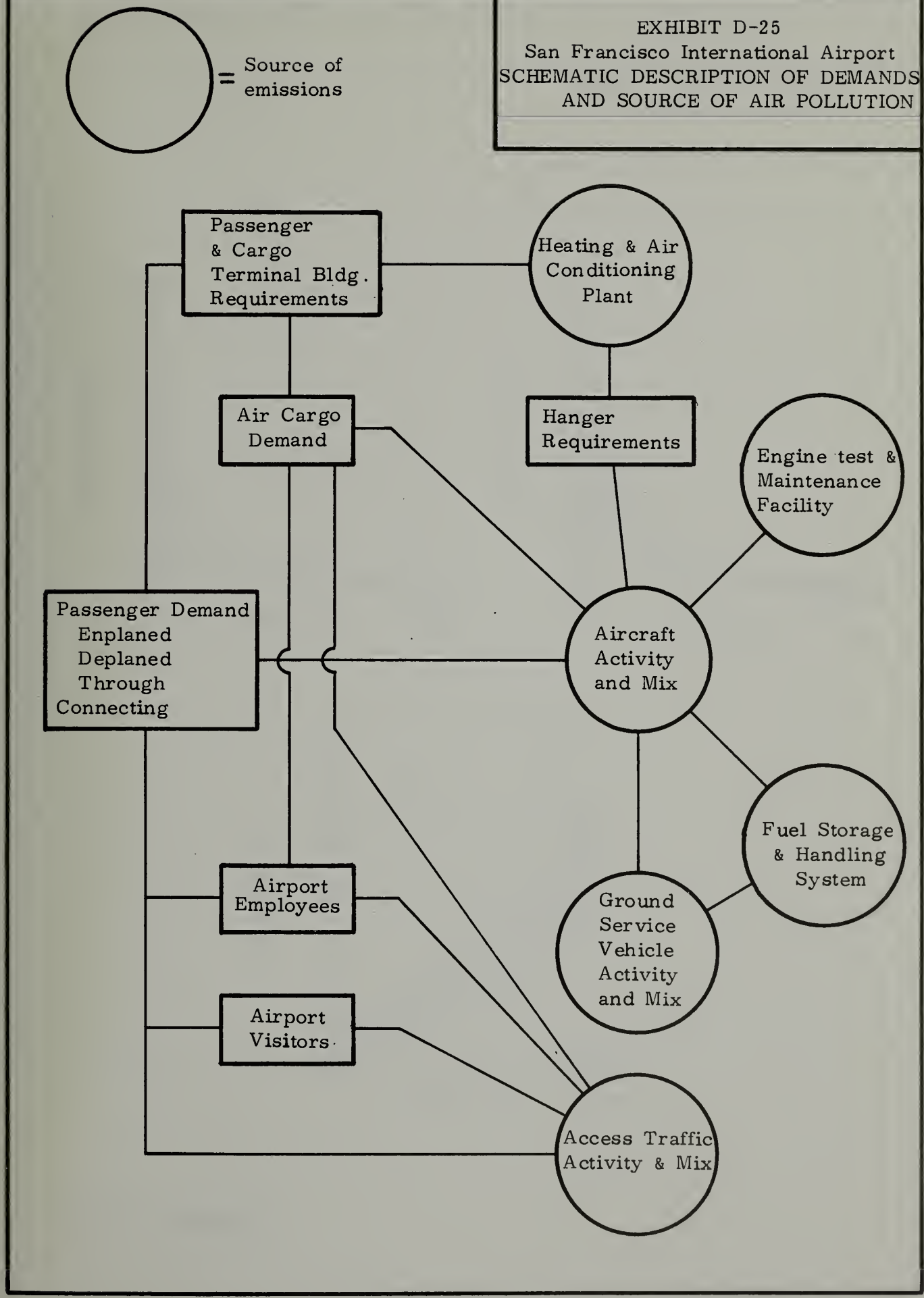
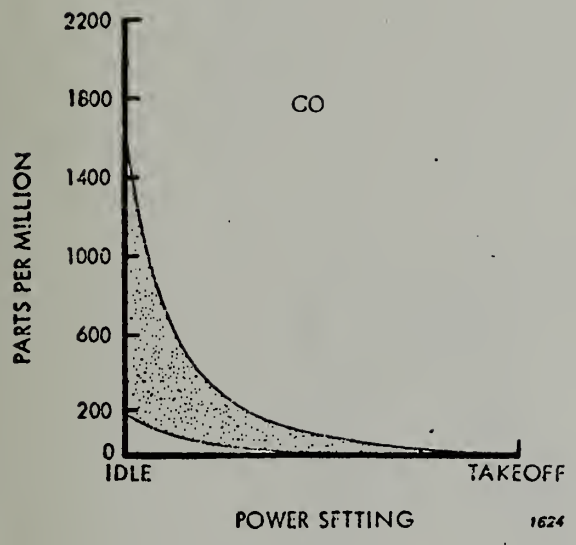
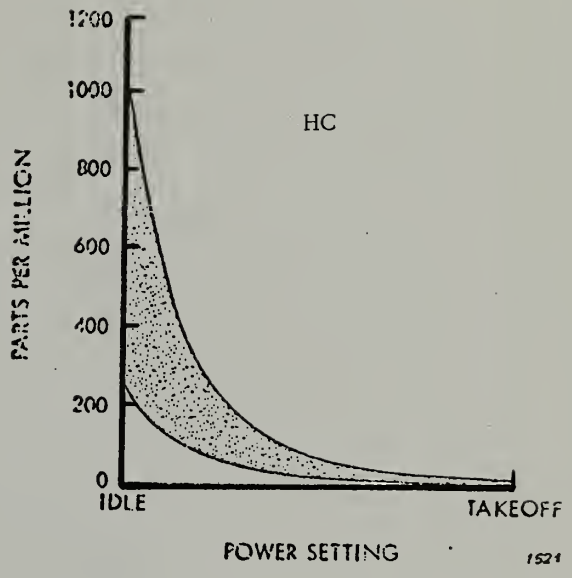
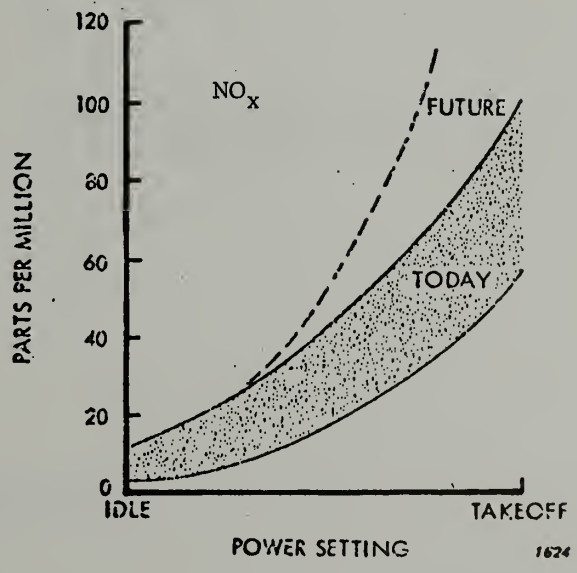


EXHIBIT D-26
San Francisco International Airport
EMISSION CHARACTERISTIC
OF AIRCRAFT ENGINES

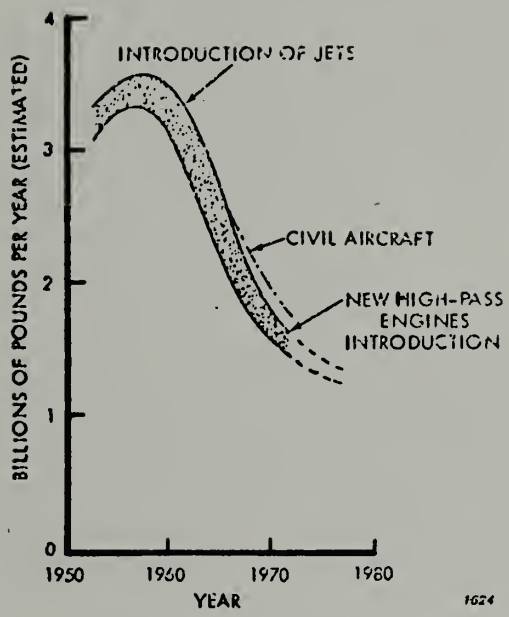






Source: Reference 1

EXHIBIT D-27
San Francisco International Airport
TRENDS IN CIVILIAN AIRCRAFT
EMISSIONS 1950-1980



Source: Reference (17)

with the introduction of jet powered aircraft. This figure further projects that the gross quantity of pollutants will continue to decrease even with increasing activity by commercial airlines.

The newer jet aircraft such as the DC-10 and 747 have generally "cleaner" engines than the 707 or DC-8, i.e., emit less particulate matter. In addition to the lowering of particulate emissions, there is a significant reduction in emission of organics from new engines. There are, however, significant increases in carbon monoxide and nitrous oxide emission. The sulphur oxide emissions are about equal for new aircraft compared to older vintage planes.

In this discussion, attention has been paid primarily to air carrier aircraft which at SFIA constitute more than 80 percent of the operations. Military and general aviation operations represent the remainder, and are included in subsequent analysis. However, no improvement in emission rates of these latter types has assumed to take place within the planning years of this study.

2. Pollutants from Vehicles

Since SFIA is the major airport in the nine county Bay Area, there is significant motor vehicle traffic travelling to and from the airport. Ground transportation is therefore a significant source of airport-related air pollution emissions. Passengers, visitors, employees and cargo vehicles all come to and leave the airport in a multiplicity of vehicle types: cars, light duty trucks, buses, heavy duty trucks, both gasoline and diesel fueled, and motorcycles.

In attempting to analyze the impact of ground access vehicle operations at the airport, several factors have to be considered.

- The emission rates of the various types of vehicles
- The mix of vehicles in the operating fleet
- The speed at which vehicles travel
- The distance over which they travel
- The time spent in the idling mode

In the analysis undertaken to assess air quality impacts all of these factors have been included, although some simplification has been introduced.

As has been discussed previously, there exists a transportation control plan which is designed to reduce the emissions of motor vehicle generated pollutants. Achievement of the goals of this plan will yield reduced pollution from vehicles accessing the airport as well as those in the general transportation region.

3. Service Vehicles

Each aircraft operation at SFIA requires some service during its landing and takeoff (LTO) cycle. In the case of general aviation aircraft, this requirement may only be delivery of fuel. In the case of air carrier aircraft between five and ten vehicles service the aircraft for each LTO. These service vehicles load and unload passengers and cargo, and provide refueling, housekeeping and maintenance service. In some cases towing vehicles are used to move planes into or away from docking gates.

The ground support equipment spends a large proportion of its total operating time motionless but with the engine at other than idle. Very little data is available on emission rates from any vehicles in this operating mode. Also, the maintenance on ground support equipment is relatively poor. With the exception of the more expensive pieces of equipment (such as the pushback tractors for the 747), the general airline feeling is that it is more cost-effective to replace a deteriorated engine in a service vehicle than it is to institute a regular maintenance program. These factors combine to make one anticipate different emission patterns between these vehicles and the normal urban traffic, even though the majority of the ground service vehicles are just specially adapted trucks from a standard production line.

Emission rates for ground service vehicles have been empirically developed and the impact of ground service vehicles on air quality is included in the analysis.

4. Stationary Sources of Pollutants at SFIA

There are four major potential stationary sources of air pollution at SFIA.

- The United Airlines maintenance facility
- The heating plant for the Terminal buildings
- Heating and air conditioning plants at hangar facilities
- The fuel storage and transfer facilities

In addition, there are approximately thirty-five automobile parking lots of various size scattered throughout the airport.

The United Airlines (UAL) maintenance facility at SFIA is the principal service facility for that airline. It is also one of the major employers at the airport. For these reasons it is the major stationary source on site. It has been designated a major point source by the BAAPCD.[1/] The operation of a turbine engine maintenance and overhaul facility by the UAL base accounts for the majority of pollutants emitted therefrom. The operation of a turbine engine maintenance and overhaul facility at an airport involves the testing of aircraft engines to insure proper performance and structural integrity. A test consists of running the engine mounted either on a special test stand or on the airplane through a set of typical flight conditions while measurements of performance are made. Since a substantial number of such tests are performed the air pollutant emissions can be significant. The BAAPCD estimates the 1973 emissions were as shown in the table below.

Estimated Emissions for 1973
United Airlines Maintenance Base

Pollutant	Emissions (Tons/Day)
Particulates	0.1
Organics	0.1
Nitrous Oxides	0.4
Sulphur Oxides	Not Indicated
Carbon Monoxide	0.2

Source: Reference (7)

1/ This does not imply the facility is a violator of BAAPCD regulations.

Emissions from this source as well as from the parking lots maintained by UAL are included in the analysis of impacts on air quality.

The heating and air conditioning plant for the terminal uses natural gas as a primary fuel. Fuel oil is available on a standby fuel, and has had to be used only a few times for short periods during the last few years.

According to data supplied by Pacific Gas and Electric Company, the supplier of natural gas to SFIA, about 138 million cubic feet (mcf) are consumed per year in heating the terminal complex. Projections of anticipated gas requirements to accommodate the expanded terminal facility indicate about 350 mcf will be required in 1982 and beyond. On this basis, and using the emission rates for natural gas consumption as given by EPA (18), the current and projected emissions due to terminal heating are as shown in Exhibit D-28. All of these emissions are orders of magnitude below the emissions of aircraft and motor vehicles. Heating and air conditioning of hangars, cargo areas as well as other airport buildings, is of even less significance. These stationary sources are not considered in subsequent analyses.

There are three major fuel storage facilities at the airport: one at the north end near the Seaplane Harbor, one near the terminal facility close to the airfield itself, and one along the Old Bayshore highway. More than ninety percent of the aviation fuel handled by these facilities is of the kerosene type and is of such low vapor pressure that emissions are negligible. Gasolene used by tank trucks to haul aviation fuel is much more volatile and contributes most to emissions from these sources. Estimates of emissions from this source range from 0.1 to 0.2 tons per day of organics and are insignificant when compared to the other sources. Thus, the fuel handling stationary sources of pollution are not considered further in the analysis.

Parking lots are potential sources of air pollution since automobiles operating within these lots are generally operating in the inefficient idling mode. Parking lots are included in the analysis of air quality.

EXHIBIT D-28
San Francisco International Airport
EMISSION OF AIR POLLUTANTS
FOR HEATING PLANT

Airport Development	Fuel Consumption (VNcf)	Emissions Tons/Year				
		Particulate	Sulphur Oxide	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Present Terminal Configuration	138	0.7	0.1	1.4	0.5	8.3
Expanded Terminal	350	1.8	0.1	3.6	1.3	21.0

5. Other Considerations

Two other areas of concern regarding the influence of airport activities on air quality are discussed below.

. Lead

The State of California has an ambient air quality standard for lead, which is given as 1.5 micrograms per cubic meter, thirty day average (19). Since significant amounts of lead had been found in the ambient air around airports, the BAAPCD made special analysis of high volume air samples to determine concentration of lead. A sampling station at the Burlingame Sewage Plant was set up not designed so much to monitor community air pollution as to document a special situation. With its most frequent northwest wind this site is downwind of a long stretch of Bayshore Freeway, and it thus monitors maximum freeway build-up of lead and other particulates, particularly for the most adverse case of wind parallel to a line source. Also with a northeast wind it monitors a major runway of San Francisco International Airport, again with parallel winds along a line source. This monitor records by far the highest lead values in the District. The station's annual average was 2.68 micrograms per cubic meter in 1970, 2.20 in 1971, 2.13 in 1972, and 1.67 in 1973 (20). According to the BAAPCD the relationship to traffic near the stations suggests that the contaminant has a fine grained distribution like that of carbon monoxide, closely related to automotive traffic (21).

. Construction Impacts

Air pollutants involved in the construction of airport improvements will include dust, smoke, and vehicular exhaust emissions. Both the Federal Aviation Administration (22) and the EPA (23) have suggested measures for preventing air pollution during construction projects.

Since a portion of the remaining construction under the SFIA expansion program will not involve extensive earthwork or pouring, the potential impacts will be somewhat less than otherwise. Efforts will be made by the airport management to minimize these impacts.

4. EVALUATION METHODOLOGY

The air quality evaluation included both emission inventory and atmospheric dispersion modeling techniques. This approach provided a thorough examination of the effects of the SFIA expansion program on air quality. Detailed descriptions of the modeling techniques, associated data base, and evaluation scenarios are presented in the sections which follow.

(1) Methodology

In order to evaluate the impact of air quality in airport vicinities, a model of airport emissions (emission inventory) and atmospheric dispersion of those emissions is required. The quantification of airport emissions is determined by identification of air pollution sources and the subsequent evaluation of their respective emission rates. Simulation of airport air quality by atmospheric dispersion requires the accurate assessment of the temporal and spatial emission patterns.

Both the emission inventory and dispersion modeling involved the tabulation of such parameters as air traffic density by engine, make, and model of aircraft; fuel usage of different aircraft; pollution emission rates by engine model and operational mode; the allocation of emission rates to the respective runways, turnoff

points, taxiways, terminal piers and gates, and parking areas; the time each aircraft spends in different operational modes; etc. Using these data and the appropriate meteorological information, average and maximum surface concentration can be calculated and compared, for example, with ambient air quality standards.

1. Emission Inventory

Airport-related activities can be functionally separated into two broad categories--those which occur within the airport boundaries and those associated with the land use and ground transportation activities which are external to the airport and are presumed to be related to or induced by the presence of the airport facility. Each of these activities can be quantified in terms of an easily determined or measurable descriptor.

Among the activities which are associated with the source of air pollution emissions in the vicinity of an airport, are:

- Aircraft operations and run-ups
- Ground service vehicles
- Access traffic on and in the near vicinity of the airport
- Motor vehicle traffic in the near vicinity of the airport but not accessing the airport
- Fuel storage and distribution
- Stationary sources within the airport

The airport vicinity emission sources which are considered to be of major significance and, therefore, must be considered in the emission inventory, include:

- Aircraft emissions during the start-up, idle, and shutdown modes at the terminals
- Aircraft emissions during the taxi mode

- Aircraft emissions during the delay-at-runway mode at the heads of the runways

- Aircraft emissions during the landing and take-off modes, while the aircraft is still on the ground

- Aircraft emissions during the approach and climb-out modes below approximately 3,500 feet above ground level

- Ground service vehicle emissions

- Motor vehicle emissions on nearby roadways, airport access roads, and parking lots

- Fuel storage and distribution emissions

- Stationary source emissions on airport

Thus, the contribution to total emissions can be calculated from the emission factors of each of the above sources and operating characteristics provided as input data.

2. Dispersion Model

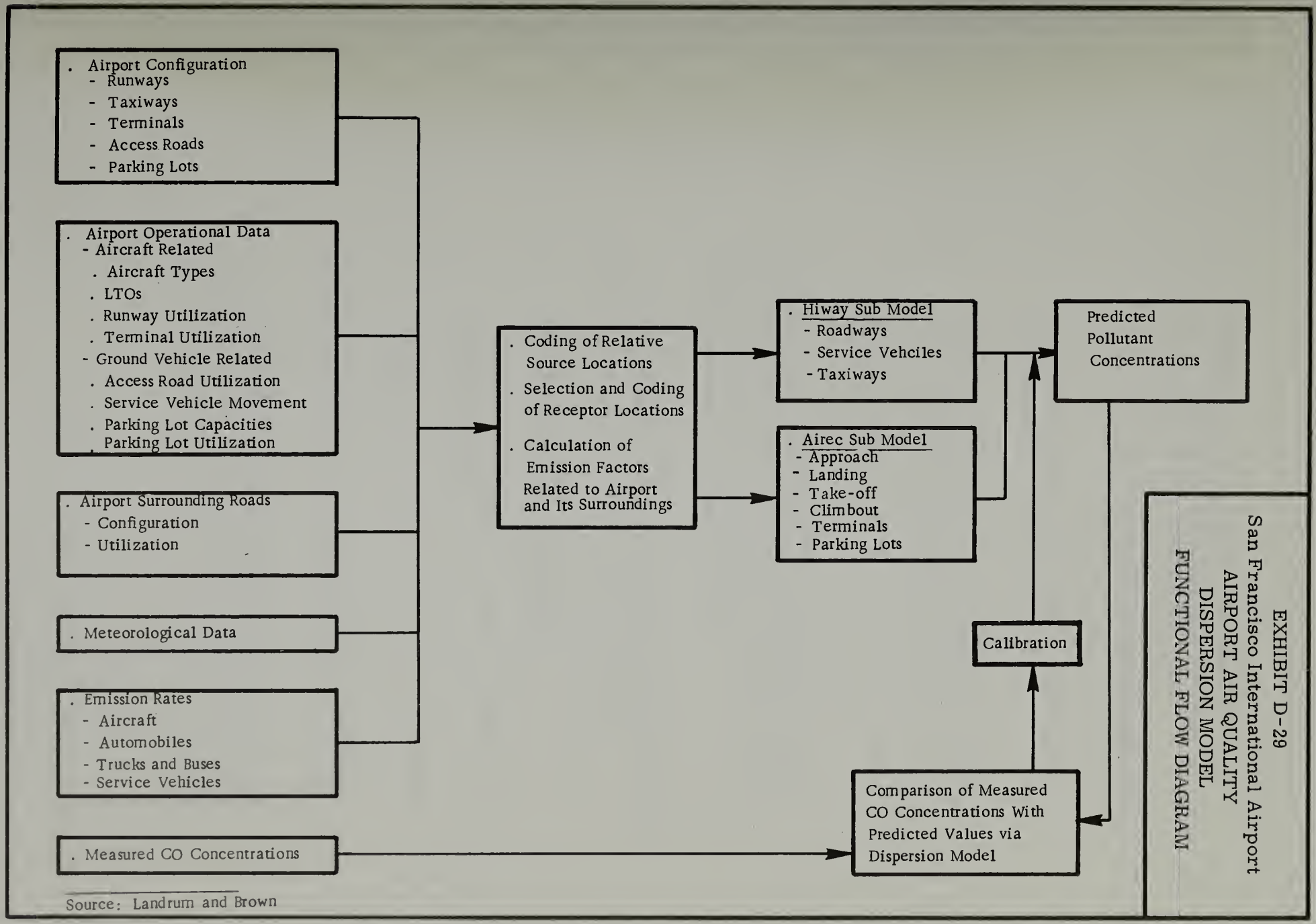
The step following the determination of airport-related air pollution emission rates is to transform the computed emission inventory into air pollution concentrations via dispersion modeling. This process is depicted by a flow diagram presented as Exhibit D-29, on the following page.

Two types of data are necessary to assess the air quality in the vicinity of an airport:

- Data to calculate pollutant emission rates in the airport vicinity

- Data to calculate the concentrations which result from dispersion of the pollutants

The first set of data are provided by the emission inventory. The data which are necessary to calculate the concentration of pollutants which result from dispersion of airport-related emissions consist of:



Source: Landrum and Brown

- Airport layouts which give the locations of terminals, taxiways, runways, roadways, fuel storage areas, parking lots, etc.

- Aircraft activity by runway, taxiway, terminals, etc.

- Locations of the various features of the airport surroundings

- Relative frequencies of all combinations of wind speed, wind direction, and atmospheric stability class, based on historical data at airport

- Mixing heights of the atmosphere during peak-hour periods

The first three items listed above are required to locate the various sources of emission and to select receptor locations at the airport. The latter two listed items are the meteorological data required to analyze the dispersion of emissions from individual sources.

At present, there are a number of dispersion models which have been developed, under federal assistance, for use in computing airport air quality, including:

- Northern Research and Engineering Corporation (NREC) Model (EPA sponsored)

- Geomet, Inc. (modified version of the NREC model, sponsored by EPA)

- Argonne Airport Air Pollution Model (sponsored by FAA).

A complete description of these models are presented in selected references listed at the end of this appendix.

The dispersion model employed in this study is based on a modified version of the NREC airport model. In addition, portions of the EPA line source dispersion model, acronym HIWAY (24), are utilized for simulation

of certain aircraft ground movements and all ground vehicle movements. The dispersion model considers a variety of emission sources, including point, line, variable line, and area. The simulation of these various sources accounts for the full spectrum of airport-related activities which generate air pollution.

The dispersion model is based on a gaussian plume algorithm, and uses a one-hour averaging time. The algorithm represents practical application of binormal continuous plume dispersion. Estimates of dispersion are those of Pasquill as restated by Gifford. Diffusion equations are based on the Workbook of Atmospheric Dispersion Estimates, D. Bruce, Turner, U.S. EPA, 1970(3). The dispersion equation which is the basis of the model is as follows:

$$\frac{X}{Q} = \frac{1}{2\pi\mu\sigma_y\sigma_z}\left\{\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\right\}\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right]\right.$$

$$+ \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right] + \sum_{N=1}^{N=K}\left[\exp -\frac{1}{2}\left(\frac{z-H-2NL}{\sigma_z}\right)^2\right.$$

$$+ \exp -\frac{1}{2}\left(\frac{z+H-2NL}{\sigma_z}\right)^2 + \exp -\frac{1}{2}\left(\frac{z-H+2NL}{\sigma_z}\right)^2$$

$$\left.\left. + \exp -\frac{1}{2}\left(\frac{z+H+2NL}{\sigma_z}\right)^2\right]\right\}$$

Where $\frac{X}{Q}$ = relative concentration

X = pollutant concentration (grams/meter^3)

Q = source emission rate (grams/second)

μ = wind velocity (meters/second)

H = source height (meters)

z = receptor height (meters)

σ_y, σ_z = dispersion coefficients

The dispersion model of airport emissions involves two categories of physical parameters:

- Source parameters which consist of the strength and location of emission sources with respect to a receptor[1/]

- Meteorological parameters which consist of atmospheric stability, wind speed, wind direction, and mixing height.

The dispersion model classifies the emissions by the type of source producing them. Emissions which are generated over a large area (for example: ground service activity in the terminal area, automobile movement in the parking lots, fuel evaporation from the filling of vehicle tanks, etc.) are classified as line sources. Emissions emanating from a very small area (for example: heating plants, power plants, etc.) are classified as point sources. The dimensions and coordinates of these sources, a first-order approximation of spatial distribution were obtained from an aerial photograph of the airport surroundings.

The gaussian plume dispersion model utilizes the point, area, and line source parameters calculated by the airport activity/emissions model and combines them with meteorological information that is relevant to the area to compute pollutant concentrations. Since the input emission inventory is both spatially and diurnally distributed, the resultant pollutant concentrations are also spatially and diurnally distributed.

To summarize, the projected airport and airport vicinity emission rates can readily be translated into air quality concentrations by means of the dispersion model. The data, as presented, needs only to be modified to show spatial distribution in order to serve as direct input into the dispersion model.

(2) Data Base

The data base utilized in the air quality analysis consisted of field measurements of air quality in the vicinity of SFIA, emission

1/ A receptor in this context is defined as the location at which the pollution concentration is calculated, usually five feet above ground level corresponding to shoulder height of the average human.

factors for airport-related sources, historical meteorology and operational data as documented in Appendices A and C of this report. The pertinent data base are presented in detail in the sections which follow.

1. Air Quality Measurements

Air quality measurements at SFIA were conducted during the course of the environmental assessment study. The measurements were taken during the week of January 6, 1975.

The measurements were conducted primarily for calibration purposes of the dispersion model. The results in no way typify ambient air quality at SFIA or its environs. The duration of the sampling period--one week--is much too short a period to draw valid conclusions regarding existing conditions. However, the results are vital to the prediction of future conditions and are indicative of ambient air quality which existed during the one week sampling period.

Air quality monitoring was limited to carbon monoxide. Since this chemical specie is relatively unreactive it is suitable for dispersion model calibration purposes. Measurements were conducted in accordance with the reference methods of the U.S. EPA as published in Federal Register, Volume 36, No. 228, November 25, 1971. Simultaneous with the air quality measurements, ground access traffic movements, aircraft movements and local meteorology were recorded.

A total of seven measurement sites were selected for round-the-clock continuous monitoring in the vicinity of SFIA. Exhibit D-30, following this page, illustrates the sampling locations. These locations were chosen to reflect current atmospheric conditions and to provide a basis for prediction of future pollution concentration levels at sensitive public areas, adjacent communities, and other critical areas.

EXHIBIT D-30
San Francisco International Airport
FIELD MEASUREMENT LOCATIONS

The monitoring was conducted by automatically collecting gas samples in five-liter mylar bags installed in a programmable continuous sampling device. The automatic air quality sampler is designed to accommodate up to twenty-four sample bags giving the system round-the-clock capability. Each sample bag is filled over a one hour period by receiving a metered two second injection of air each 20 seconds, or 180 injections per hour.

Laboratory analysis of the samples was determined by using a Bendix-UNOR nondispersive infrared (NDIR) analyzer. Model No. 8501-5BA. This device is on EPA's list of qualified reference method instruments for carbon monoxide determination. It has a total sensitivity of 50 parts per million (ppm), and allows accurate determination of carbon monoxide concentrations of less than 0.1 ppm. Certified standard zero and span gases were used to calibrate the NDIR.

Exhibit D-31, following this page, summarizes the measured carbon monoxide concentrations at SFIA. The one hour averages range from 0.2 to 14.7 ppm, which is below the State of California and NAAQS of 35 ppm, one hour average. The greatest levels which were measured occurred at the lower level curbside terminal area ("arrivals"). In general, the greatest levels measured occurred during daytime hours. Remote off-airport locations showed lower concentrations than those locations on airport property. The eight hour NAAQS for carbon monoxide of 9 ppm was exceeded during two of the sampling days at the lower level terminal area. The upper level curbside terminal area ("departures") showed about one-half the carbon monoxide levels as the lower level. This is apparently due to the overhead roadway structure which may tend to impede the dispersion of pollutants accumulated at the lower level. In addition, curbside idle times of curbside motor vehicles is significantly greater for "arrivals" than for "departures."

Time Frame	Mon. 1-6-75 LS	Mon. 1-6-75 US	Tues. 1-7-75 LS	Tues. 1-7-75 US	Wed. 1-8-75 LS	Wed. 1-8-75 US	Wed. 1-8-75 IR	Wed. 1-8-75 UW	Thurs. 1-9-75 IR	Thurs. 1-9-75 UW	Thurs. 1-9-75 CP	Thurs. 1-9-75 ER	Fri. 1-10-75 IR	Fri. 1-10-75 ER	Fri. 1-10-75 AP
12 Mid - 1 A.M.			12.1	3.2	5.8	2.0			ND	0.2			3.5	2.5	
1 A.M. 2 A.M.			10.8	1.8	2.5	1.3			ND	0.3			1.8	0.6	
2 A.M. 3 A.M.			7.3	1.2	2.2	0.6			ND	0.2			0.3	0.3	
3 A.M. 4 A.M.			8.2	0.7	2.6	0.8			ND	0.2			0.2	0.2	
4 A.M. 5 A.M.			6.2	1.6	3.1	0.3			ND	0.2			0.2	0.2	
5 A.M. 6 A.M.			4.5	3.1	0.5	0.3			3.3	0.2			0.2	0.2	
6 A.M. 7 A.M.			4.4	3.4	1.9	2.0			5.4	1.5			3.1	1.0	
7 A.M. 8 A.M.	2.0	3.2	7.0	6.6	6.0	3.9			ND	4.1			4.4	2.7	
8 A.M. 9 A.M.	4.0	2.1	9.9	9.5	7.8	4.0			4.7	2.6				2.6	2.1
9 A.M. 10 A.M.	5.0	1.7	10.2	5.4	7.5	3.6			3.9	1.9				1.8	1.0
10 A.M. 11 A.M.	6.8	1.4	8.2	3.7	8.1	3.9			2.8	0.8				1.7	0.7
11 A.M. 12 Noon	8.1	2.5	7.5	2.9	13.7	4.7			2.5	0.6				1.6	0.8
12 Noon 1 P.M.	12.6	3.5	7.4	3.9			2.9	1.1	2.6	0.4				1.8	0.6
1 P.M. 2 P.M.	11.0	2.9	7.8	3.6			2.6	0.5	2.8	0.2				2.4	4.7
2 P.M. 3 P.M.	14.7	4.1	8.6	3.7			3.5	0.4		0.3	0.2			3.2	2.7
3 P.M. 4 P.M.	11.4	3.1	9.4	3.5			4.1	1.1			0.2	3.1		3.4	1.5
4 P.M. 5 P.M.	10.8	3.4	12.0	3.7			4.8	1.4			0.2	2.4		3.4	1.3
5 P.M. 6 P.M.	14.0	3.7	8.6	5.0			3.9	1.0			0.2	3.5		3.5	1.4
6 P.M. 7 P.M.	12.9	4.5	10.5	5.0			3.0	0.9			0.2	4.1		3.6	2.4
7 P.M. 8 P.M.	ND	4.4	10.4	5.2			2.1	0.5			0.2	3.3			
8 P.M. 9 P.M.	ND	6.2	10.7	4.3			1.4	0.4	1.8			1.7			
9 P.M. 10 P.M.	ND	4.1	9.8	4.0			1.5	0.4	2.0			2.0			
10 P.M. 11 P.M.	ND	4.0	8.5	2.9			0.6	0.3	1.8			1.9			
11 P.M. 12 Mid.	ND	3.6	4.4	1.8			ND	0.3	2.8			3.0			
Highest One-Hour Concentration	14.70	6.20	12.10	9.50	13.70	4.70	4.80	1.40	5.40	4.10	0.20	4.10	4.40	3.60	4.70
Highest Eight-Hour Concentration	*11.90	4.20	*10.80	5.60	6.80	3.20	3.30	4.90	3.50	1.50	0.20	2.90	2.00	3.10	2.10

Notes:

*Exceeds Eight-Hour Standard (9 PPM)

ND = No Data

EXHIBIT D-31

San Francisco International Airport

CARBON MONOXIDE

MONITORING DATA

2. Meteorology

The National Climatic Center in Asheville, North Carolina, maintains computerized storage and retrieval facilities for meteorological data reported by national weather stations. The National Climatic Center also operates computer programs for determining relative frequencies of all combinations of wind speed, wind direction, and atmospheric stability class based on historical meteorological data. The specific program used for this study is known as STAR, which provides wind distribution by Pasquill Stability Class.

Meteorological data have been accumulated by the National Oceanographic and Atmospheric Administration (NOAA) personnel stationed at SFIA. These data are available from the National Climatic Center.

In the dispersion modeling analysis, three meteorological regimes were investigated which have the greatest probability of occurrence in the vicinity of SFIA. These included:

- Moderately unstable atmospheric conditions
- Neutral atmospheric conditions
- Moderately stable atmospheric conditions

Each of these regimes influence ambient air quality in different ways. In general, the more stable conditions result in higher pollutant concentrations. The complete definition of these regimes requires information related to the frequency of all combinations of wind speed, wind direction, and atmospheric stability defined by the Pasquill Stability Classification. The following explanation of Pasquill Stability Classification has been extracted from an article by D. Bruce Turner in the February 1964, Journal of Applied Meteorology:

"This system of classifying stability on an hourly basis for research in air pollution is based upon work accomplished by Dr. F. Pasquill of the British Meteorological Office (1961). Stability near the ground is dependent primarily upon net radiation and wind speed. Without the influence of clouds, insolation (incoming radiation) during the day is dependent upon solar altitude, which is a function of time of day and time of year. When clouds exist, their cover and thickness decrease incoming and outgoing radiation. In this system,

insolation is estimated by solar altitude and modified for existing conditions of total cover and cloud ceiling height. At night, estimates of outgoing radiation are made by considering cloud cover. This stability classification system has been made completely objective so that an electronic computer can be used to compute stability classes. The stability classes are as follows: (A) Extremely unstable, (B) Unstable, (C) Moderately unstable, (D) Neutral, (E) Moderately stable, (F) Stable, (G) Extremely stable. Instability occurs with high positive net radiation and low wind speed, stability with high negative net radiation and light winds, and neutral conditions with cloudy skies or high wind speeds."

In the dispersion modeling analysis performed for SFIA and its environs, the effect of diurnal and seasonal variations in meteorology were considered. These variations were analyzed with respect to the diurnal and seasonal variations of aircraft and ground access operations. Exhibit D-32 summarizes the meteorological scenarios which were evaluated in the dispersion modeling effort. As indicated, both "typical" and probable "worst-case" meteorological conditions were considered. The winter months (December through February) were selected as representative of the worst-case season. This selection was based on examination of historical air quality data for the San Francisco Bay region, which indicates highest pollutant (primarily carbon monoxide, hydrocarbons and particulates) during winter periods. Three worst-case scenarios were evaluated in order to determine the absolute worst-case of the three possible situations. As indicated, the "typical" regime, as defined, has the probability of occurrence of more than one-half the year (52.3 percent of the time), while the most adverse meteorological condition, as defined, has the probability of occurrence of approximately 14 days per year (3.9 percent of the time). In actual fact, the estimate of 14 days per year is highly conservative inasmuch as the 1.0 meter/second wind speed would not occur this frequently. A more realistic estimate of the probability of occurrence of the "worst-case" meteorological condition would be less than one percent of the time, or about three days per year.

Exhibits D-33, D-34 and D-35, summarize, in part, the five-year historical meteorological data (1969-1973) which were utilized in the analysis. These exhibits present the frequency of occurrence of wind direction and stability class.

Pasquill Stability Class	Season	Time	Probability of Occurrence of Stability Class During Year (Percent of Time)	Wind Direction 1/	Wind Speed 2/ (m/sec)	Description
C - Moderately Unstable	Annual Avg.	7 to 10 a.m.	21.4	WNW	4.0	-
D - Neutral	Annual Avg.	7 to 10 a.m.	52.3	WNW	4.0	Typical
D - Neutral	Annual Avg.	7 to 10 a.m.	52.3	WNW	1.0	-
E - Moderately Stable	Dec. - Feb.	7 to 10 a.m.	3.9	WNW	1.0	"Worst-Case"
E - Moderately Stable	Dec. - Feb.	1 to 4 p.m.	3.9	WNW	1.0	"Worst-Case"
E - Moderately Stable	Dec. - Feb.	7 to 10 a.m.	3.9	ESE	1.0	"Worst-Case

1/ Most probable wind direction as given by STAR program run. The ESE direction was selected for one case to evaluate the effect of a 180 degree wind shift.

2/ Most probable wind speed as given by STAR program run. The 1.0 m/sec. was arbitrarily selected for "worst-case" conditions.

EXHIBIT D-32
San Francisco International Airport
METEOROLOGICAL
SCENARIOS EVALUATED
IN DISPERSION MODELING

EXHIBIT D-33

San Francisco International Airport

FREQUENCY OF METEOROLOGICAL CONDITIONS
BY WIND DIRECTION AND STABILITY CLASS
ANNUAL 0700-1000 HOURS

Wind Direction	Frequency of Occurrence (Percent)							
	Stability Class							
	A	B	C	D	E	F	G	Total
	Unstable			Neutral		Stable		
N	0.0031	0.77	1.32	1.68	0.12	0.12	0.04	4.05
NNE	0.0031	1.91	1.32	0.70	0.05	0.09	0	4.07
NE	0.0031	2.91	1.13	0.91	0.05	0	0.04	5.04
ENE	0.0031	3.24	1.48	1.32	0.10	0.09	0.04	6.27
E	0.0031	1.09	1.71	2.12	0.12	0.09	0	5.13
ESE	0.0031	0.47	1.61	3.40	0.25	0.17	0	5.90
SE	0.0031	0.31	1.06	3.46	0.47	0.58	0.28	6.16
SSE	0.0031	0.37	0.54	2.26	0.50	0.73	0.36	4.76
S	0.0031	0.52	0.74	3.72	0.55	1.28	1.00	7.81
SSW	0.0031	0.09	0.31	2.05	0.25	0.52	0.08	3.30
SW	0.0031	0.09	0.40	2.07	0.15	0.35	0.16	3.22
WSW	0.0031	0.19	0.51	3.69	0.07	0.23	0.24	4.93
W	0.0031	0.29	1.56	9.90	0.30	0.35	0.24	12.64
WNW	0.0031	0.54	3.79	11.26	0.62	0.87	0.20	17.28
NW	0.0031	0.45	3.14	3.16	0.25	0.29	0.08	7.37
NNW	0.0031	0.51	0.78	0.59	0.07	0.06	0.04	2.05
Calm	0.0499	1.54	0.92	0.90	0	0.82	1.05	5.28
Total	0.099	15.29	22.32	53.19	3.92	6.64	3.85	

Source: National Climatic Center, STAR computer program run for San Francisco International Airport

EXHIBIT D-34

San Francisco International Airport

FREQUENCY OF METEOROLOGICAL CONDITIONS

BY WIND DIRECTION AND STABILITY CLASS

DEC.-FEB. 1300 TO 1600 HOURS

Wind Direction	Frequency of Occurrence (Percent)							
	Stability Class							
	A	B	C	D	E	F	G	
	Unstable			Neutral	Stable			Total
N	0.006	0.44	1.69	3.96	0.29	0.22	0	6.61
NNE	0.006	0.88	2.97	4.17	0.59	0.22	0.16	8.99
NE	0.006	1.09	3.77	2.79	0.49	0.22	0.16	8.53
ENE	0.006	1.09	4.47	2.59	0.20	0.43	0	8.79
E	0.006	0.65	2.58	3.99	0.10	0.75	0	8.08
ESE	0.006	0.10	1.19	3.46	0.20	0.22	0	5.18
SE	0.006	0.11	0.89	4.04	0.10	0	0.16	5.31
SSE	0.006	0.11	0.70	3.25	0	0	0	4.07
S	0.006	0.33	1.19	7.76	0	0.11	0	9.43
SSW	0.006	0	0.10	3.54	0	0	0	3.65
SW	0.006	0	0.10	3.15	0.10	0	0	3.36
WSW	0.006	0	0	3.15	0	0.11	0	3.27
W	0.006	0.11	0.40	9.33	0.67	0	0	10.52
WNW	0.006	0	0.69	10.62	0.20	0	0	11.52
NW	0.006	0.11	0.40	1.48	0.10	0	0	2.10
NNW	0.006	0	0.20	0.49	0	0	0	0.70
Calm	0.098	0.49	0.20	0.29	0	0.20	0.20	1.48
Total	0.19	5.51	21.54	68.06	3.04	2.48	0.68	

Source: National Climatic Center, STAR computer program run for San Francisco International Airport

EXHIBIT D-35

San Francisco International Airport

FREQUENCY OF METEOROLOGICAL CONDITIONS

BY WIND DIRECTION AND STABILITY CLASS

DEC.-FEB. 0700 TO 1000 HOURS

Wind Direction	Frequency of Occurrence (Percent)							
	Stability Class							
	A	B	C	D	E	F	G	Total
	Unstable			Neutral	Stable			
N	0	0.10	1.30	3.04	0.29	0.34	0.16	5.23
NNE	0	0	1.35	1.14	0.20	0	0	2.69
NE	0	0.72	0.72	1.87	0.20	0	0.16	3.67
ENE	0	0.51	1.55	4.10	0.40	0.23	0.16	6.95
E	0	0.20	2.98	5.76	0.40	0.23	0	9.57
ESE	0	0.41	3.04	8.69	0.59	0.57	0	13.30
SE	0	0.31	2.23	7.54	1.18	1.37	0.33	12.96
SSE	0	0	0.62	4.16	1.28	1.83	0.33	8.22
S	0	0	0.31	5.62	0.98	2.86	1.64	11.41
SSW	0	0	0.10	1.83	0.79	0.69	0	3.41
SW	0	0.10	0.20	2.41	0.29	9.57	0.33	3.90
WSW	0	0	0.20	2.17	0.20	0.46	0.49	3.52
W	0	0	0.20	3.55	0.59	0.57	0.65	5.56
WNW	0	0	0.50	4.14	0.79	1.03	0	6.46
NW	0	0	0.31	1.13	0.40	0.23	0	2.07
NNW	0	0	0.21	0.41	0.20	0.11	0.16	1.09
Calm	0	0.098	0.59	1.67	0	1.57	1.77	5.70
Total	0	2.45	16.41	59.23	8.78	12.66	6.18	

Source: National Climatic Center, STAR computer program run for San Francisco International Airport

3. Emission Factors

This section presents the emission factors which were assumed for the air quality analysis. The emission rates are ostensibly based on AP-42, Compilation of Emission Factors (2). The data include emission rates for aircraft, motor vehicles and stationary sources. These data are summarized in the following exhibits:

- Exhibit D-36: Motor Vehicle Emission Factors by Mode of Operation for 1974, 1982 and 1990
- Exhibit D-37: Aircraft Emission Factors by Mode of Operation
- Exhibit D-38: Stationary Source Emission Factors

The motor vehicle emission factors were developed assuming a California vehicle fleet mix. Motor vehicle longevity and replacement rates were assumed as per AP-42. Emission control programs as currently legislated were assumed to be valid in the development of the motor vehicle emission rates.

Aircraft emission rates were assumed to remain constant from the present situation through 1990. Although aircraft emission standards have been enacted, it has been assumed that the impact of these standards would not significantly impact the aircraft fleet operating through 1990. This approach is admittedly conservative, however, in view of the present energy situation it is considered to be reasonable. On the other hand, the assumption that motor vehicle emission control programs will continue as planned has been adopted because these programs are nearly completely implemented.[1/]

4. Calibration

An important part of the application of dispersion modeling in the airport situation is the investigation of the inherent accuracy of the model and the subsequent "calibration" of the model for the application to SFIA.

1/ Refer to Exhibits D-36, D-37, and D-38 for details on assumed emission factor.

EXHIBIT D-36

San Francisco International Airport

GROUND VEHICLE CARBON MONOXIDE, HYDROCARBON, NITROGEN OXIDE, PARTICULATE AND SULPHUR DIOXIDE EMISSION FACTORS BY MODE OF OPERATION

Vehicle Type	Year	Emissions By Operating Mode (Gm/Mile)									
		Carbon Monoxide		Hydrocarbon		Nitrogen Oxide		Particulate		Sulphur Dioxide	
		Idle 2/	Travel	Idle	Travel	Idle	Travel	Idle	Travel	Idle	Travel
Automobile	1974	97.2	49.19	7.92	4.56	0.72	4.00	0.34	0.54	0.13	0.13
	1982	15.79	7.99	1.48	0.85	0.20	1.11	0.34	0.54	0.13	0.13
	1990	6.04	3.06	0.64	0.37	0.09	0.54	0.34	0.54	0.13	0.13
Trucks 1/ Bus	1974	144.30	96.20	20.51	13.67	15.72	17.47	0.58	0.93	0.26	0.26
	1982	108.65	72.43	8.34	5.56	11.81	13.12	0.58	0.93	0.26	0.26
	1990	90.59	60.39	5.66	3.77	11.01	12.23	0.58	0.93	0.26	0.26
Service Vehicle	1974	126.79	64.2	19.45	17.67	2.11	11.71	0.17	0.30	0.14	0.14
	1982	56.5	28.5	5.31	4.83	1.62	8.96	0.17	0.72	0.14	0.14
	1990	11.80	5.99	2.55	2.32	1.05	5.78	0.17	0.15	0.14	0.14

1/ Assuming 2/3 Heavy Duty Gasoline and 1/3 Heavy Duty Diesel Powered Vehicles

2/ Equivalent to a Vehicle Traveling at 10 mph

Source: Compilation of Air Pollution Emission Factors, AP-42 U. S. EPA 2nd Edition April, 1973 and Supplements, and Landrum and Brown estimates

EXHIBIT D-37-1

San Francisco International Airport

AIRCRAFT CARBON MONOXIDE EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974

Aircraft Description and Representative Type	Approach (Gms/Oper.)	Landing (Gm/M)	Taxi (Gms/Sec.)	Idle and Shutdown (Gms/Oper)	Start-up and Idle (Gms/Oper)	Take-off (Gms/M)	Climb-out (Gms/Oper)
1. 4 Eng. Turbojet (JT4), B707-, B720	3170	0.194	31.65	950	950	0.415	996
2. 4 Eng. Turbofan (JT3D), B707, DC-8	4800	0.293	54.88	1650	16500	0.272	833
3. 3 Eng. Turbofan (JT8D), B727	1730	0.076	12.62	380	3800	0.099	363
4. 2 Eng. Turbofan (JT8D), DC-9, B737	1160	0.054	8.41	253	2530	0.066	242
5. 4 Eng. HBPRFan (JT9D), B-747	3750	0.301	51.35	1540	15400	0.128	637
6. 3 Eng. HBPRFan (CF6-6), DC-10, L1011	1600	0.129	19.52	587	5870	0.078	269
7. 4 Eng. Turboprop (T56-A1J), DC-6	474	0.023	4.41	132	1320	0.053	210
8. 2 Eng. Turboprop (T56-A15), CU580	237	0.012	0.89	66	660	0.045	105
9. Gen. Av. Jet (JT12A) Learjet	469	0.072	2.20	955	9550	0.055	105
10. 2 Eng. Piston Utility (Lycoming 0-320) Cessna 310	1390	0.069	2.79	84	838	0.783	4050
11. 1 Eng. Piston Utility (Lycoming 0-320) Cessna 172	684	0.034	1.40	63	627	0.362	1680
12. Helicopter (S-61) (G. E. CT-58)	253	0	0	7.2	72.3	0	45.7

Source: Compilation of Air Pollution Emission Factors, AP-42 U. S. EPA, 2nd Edition April, 1973 and Supplements

EXHIBIT D-37-2

San Francisco International Airport

AIRCRAFT HYDROCARBON EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974

Aircraft Description and Representative Type	Approach (Gms/Oper)	Landing (GM/M)	Taxi (Gms/Sec.)	Idle and Shutdown (Gms/Oper)	Start-up and Idle (Gms/Oper)	Take-off (Gms/M)	Climb-out (Gms/Oper)
1. 4 Eng. Turbojet (JT4), B707-, B720	464	0.028	32.33	980	9800	0.15	69.10
2. 4 Eng. Turbofan (JT3D), B707, DC-8	949	0.058	49.19	1490	14900	0.10	268
3. 3 Eng. Turbofan (JT8D), B727	167	0.007	2.62	92.8	928	0.010	37.6
4. 2 Eng. Turbofan (JT8D), DC-9, B737	111	0.005	1.74	61.8	618	0.007	25.10
5. 4 Eng. HBPRFan (JT9D), B-747	344	0.028	13.62	413	4130	0.046	144
6. 3 Eng. HBPRFan (CF6-6), DC-10, L1011	163	0.013	5.76	175	1750	0.015	53.10
7. 4 Eng. Turboprop (T56-A1J), DC-6	44.40	0.002	3.68	112	1120	0.006	24.70
8. 2 Eng. Turboprop (T56-A15), CU580	22.20	0.001	1.84	55.8	558	0.005	12.30
9. Gen. Av. Jet (JT12A) Learjet	3.20	0.0005	1.84	147	1470	0.005	7.42
10. 2 Eng. Piston Utility (Lycoming 0-320) Cessna 310	28.50	0.0014	0.09	2.67	2670	0.016	80.70
11. 1 Eng. Piston Utility (Lycoming 0-320) Cessna 172	10.90	0.0005	0.045	1.77	17.70	0.005	22.20
12. Helicopter (S-61) (G.E. CT-58)	23.60	0	0	5.64	56.40	0	4.26

Source: Compilation of Air Pollution Emission Factors, AP-42 U.S. EPA 2nd Edition, April, 1973 and Supplements

EXHIBIT D-37-3
San Francisco International Airport
AIRCRAFT NITROGEN OXIDES
EMISSION FACTOR BY MODE OF
OPERATION FOR THE YEAR 1974

Aircraft Description and Representative Type	Approach (Gms/Oper)	Landing (Gm/M)	Taxi (Gms/Sec.)	Idle and Shutdown (Gms/Oper)	Start-up and Idle (Gms/Oper)	Take-off (Gms/M)	Climb-out (Gms/Oper)
1. 4 Eng. Turbojet (JT4), B707-, B720	4350	0.265	1.34	41.0	410	5.20	8440
2. 4 Eng. Turbofan (JT3D), B707, DC-8	2640	0.161	0.71	21.6	216	3.26	5230
3. 3 Eng. Turbofan (JT8D), B727	2940	0.128	1.08	33.0	330	2.62	5350
4. 2 Eng. Turbofan (JT8D), DC-9. B737	1960	0.085	0.73	22.0	220	1.75	3560
5. 4 Eng. HBPRFan (JT9D), B-747	6210	0.498	3.02	91.7	917	11.1	25000
6. 3 Eng. HBPRFan (CF6-6), DC-10, L1011	14500	1.200	1.35	40.7	407	6.25	13600
7. 4 Eng. Turboprop (T56-A1J), DC-6	996	0.048	0.62	18.7	187	0.397	1380
8. 2 Eng. Turboprop (T56-A15), CV580	498	0.024	0.31	9.33	93.3	0.333	689
9. Gen. Av. Jet (JT12A) Learjet	982	0.015	0.24	5.49	54.9	0.023	38.2
10. 2 Eng. Piston-Utility (Lycoming 0-320) Cessna 310	2.9	0.001	0.0031	0.0900	0.90	0.0024	23
11. 1 Eng. Piston Utility (Lycoming 0-320) Cessna 172	1.5	0.001	0.0025	0.080	0.80	0.619	7.9
12. Helicopter (S-61) (G.E. CT-58)	166	0	0	7.23	72.3	0	266

Source: Compilation of Air Pollution Emission Factors, AP-42 U.S. EPA 2nd Edith, April, 1973 and Supplements

EXHIBIT D-37-4

San Francisco International Airport

AIRCRAFT PARTICULATES

EMISSION FACTOR BY MODE OF

OPERATION FOR THE YEAR 1974

Aircraft Description and Representative Type	Approach (Gms/Oper)	Landing (Gm/M)	Taxi (Gms/Sec.)	Idle and Shutdown (Gms/Oper)	Start-up and Idle (Gms/Oper)	Take-off (Gms/M)	Climb-out (Gms/Oper)
1. 4 Eng. Turbojet (JT4), B707-, B720	720	0.044	0.59	18	180	0.462	1090
2. 5 Eng. Turbofan (JT3D), B707, DC-8	960	0.059	0.23	6.67	66.60	0.180	468
3. 3 Eng. Turbofan (JT8D), B727	143	0.006	0.14	3.99	39.90	0.050	108
4. 2 Eng. Turbofan (JT8D), DC-9, B737	95.20	0.004	0.09	2.67	26.70	0.033	72
5. 4 Eng. HBPRFan (JT9D), B-747	25.30	0.020	1.09	33.30	333	0.058	216
6. 3 Eng. HBPRFan (CF6-6), DC-10, L1011	38	0.003	0.015	0.510	5.10	0.006	21.60
7. 4 Eng. Turboprop (T56-A1J), DC-6	420	0.020	0.80	24.3	243	0.053	191
8. 2 Eng. Turboprop (T56-A15), CV580	210	0.010	0.40	12.2	122	0.045	95.50
9. Gen. Av. Jet (JT12A) Learjet	20.8	0.003	0.08	0.50	5.00	0.005	7.40
10. 2 Eng. Piston Utility (Lycoming 0-320) Cessna 310	1.30	0.0001		0.50	5.00	0.0012	6.80
11. 1 Eng. Piston Utility (Lycoming 0-320) Cessna 172	0.60	0.00003		0.17	1.70	0.0006	2.70
12. Helicopter (S-61) G.E. CT-58)	58.5	0	0	2.34	23.40	0	47.90

Source: Compilation of Air Pollution Emission Factors, AP-42, U.S. EPA 2nd Edition April, 1973 and Supplements

EXHIBIT D-37-5
San Francisco International Airport
AIRCRAFT SULPHUR OXIDES
EMISSION FACTOR BY MODE
OF OPERATION FOR THE YEAR 1974

	Aircraft Description and Representative Type	Approach (Gms/Oper)	Landing (Gm/M)	Taxi (Gms/Sec.)	Idle and Shutdown (Gms/Oper)	Start-up and Idle (Gms/Oper)	Take-off (Gms/M)	Climb-out (Gms/Oper)
1.	4 Eng. Turbojet (JT4), B707-, B720	145	0.089	1.65	49.5	495	0.239	174
2.	4 Eng. Turbofan (JT3D), B707, DC-8	100	0.061	1.42	42.6	426	0.167	45.91
3.	3 Eng. Turbofan (JT8D), B727	61.90	0.038	0.92	27.6	276	0.101	27.82
4.	2 Eng. Turbofan (JT8D), DC-9, B737	41.27	0.025	0.62	18.5	185	0.068	18.55
5.	4 Eng. HBPRFan (JT9D), B-747	126	0.077	1.65	49.5	495	0.25	72.26
6.	3 Eng. HBPRFan (CF6-6), DC-10, L1011	112.66	0.069	0.90	37	270	0.16	42.74
7.	4 Eng. Turboprop (T56-A1J), DC-6	31.22	0.022	0.37	11.10	110	0.028	7.20
8.	2 Eng. Turboprop (T56-A15), CV580	15.62	0.011	0.19	5.70	57	0.014	3.62
9.	Gen. Av. Jet (JT12A) Learjet	8.54	0.005	0.202	6.1	61	0.002	2.00
10.	2 Eng. Piston Utility (Lycoming 0-320) Cessna 310	0.42	0.0003	.014	.41	4.1	0.0005	0.060
11.	1 Eng. Piston Utility (Lycoming 0-320) Cessna 172	0.19	0.0002	.007	.21	2.1	0.0002	0.22
12.	Helicopter (S-61) (G.E. CT-58)	4.05	0	0.27	8.1	8.1	0	

Source: Compilation of Air Pollution Emission Factors, AP-42 U.S. EPA 2nd Edition, April, 1973 and Supplements

Emission Factors for Natural Gas Combusion (lb/$10^6 m^3$)

Type of Unit	Carbon Monoxide	Sulphur Oxides a/	Particulates	Hydrocarbons	Nitrogen Oxides
Power Plant	17	0.60	15	1.0	600
Domestic and Commercial Heating	20	0.60	19	8	80

a/ Based on average sulphur content of natural gas of 4600 g/$10^6 m^3$

Source: Compilation of Air Pollutant Emission Factors, AP-42
2nd Edition April, 1973 and supplements

EXHIBIT D-38-1
San Francisco International Airport
STATIONARY SOURCES EMISSION FACTORS

Hydrocarbon Emission Factors for Evaporation Losses From Storage of Petroleum Products			
		Type of Material Stored	
Type of Tank	Units	Gasoline or Finished Petroleum Product	Crude Oil
Fixed Roof Breathing Loss	lb/day - 100 gal. Storage capacity	0.40	0.30
Working Loss	lb/1000 gal. Throughput	11	8

Source: Compilation of Air Pollutant Emission Factors, AP-42
2nd Edition April, 1973 and Supplement

EXHIBIT D-38-2
San Francisco International Airport
STATIONARY SOURCES EMISSION FACTORS

Type of Unit Industrial and Commercial	Emission Factors for Fuel Oil Combustion Pollutant (lb/10^3 gal)				
	Particulate	Sulphur Dioxide	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Power Plant	8	157S[1/]	3	2	105
Residual	23	157S	4	3	80
Distillate	15	142S	4	3	80
Domestic	10	142S	5	3	12

1/ S equals Percent by Weight of Sulphur in the Oil

Source: Compilation of Air Pollutant Emission Factors, AP-42
2nd Edition April, 1973 and Supplements

EXHIBIT D-38-3
San Francisco International Airport
STATIONARY SOURCES EMISSION FACTORS

Because of a multitude of scientific and technical limitations, the dispersion modeling employed in the analysis provides "best estimates" of air quality conditions but are not infallible predictions. Furthermore, the confidence level for predicting nonreactive pollutants, such as carbon monoxide or particulates, is greater than for reactive pollutants, such as hydrocarbons and oxides of nitrogen.1/

To provide a check of the calculated pollutant concentrations via the dispersion model, a comparison was made with the actual measured air quality and related traffic obtained during the week of January 6, 1975 at SFIA, and the results obtained with the model. The results of the "calibration" are summarized in Exhibit D-39. As indicated on the Exhibit, the difference in values between those calculated and those measured does not exceed 1.0 ppm. Furthermore, the results of the dispersion modeling provide a conservatively high estimate of actual conditions. Because the modeling results are indeed conservative, no significant adjustment was made to the calculated pollutant concentrations.

(3) Evaluation Scenarios

The evaluation scenarios selected for the air quality analysis considered the effects of airport configuration, operation levels, atmospheric conditions, and seasonal and diurnal variations of operation levels and atmospheric conditions. Exhibit D-40 depicts a total of twenty-four basic scenarios which were analyzed.

The results of the air quality analysis presented in the next section, focus upon conditions predicted to exist during "typical" and during "worst-case" conditions. These conditions are defined as follows:

1/ The complex chemistry which generates photochemical smog involves hydrocarbons, nitrogen oxides, and ultraviolet radiation from the sun. The detailed mechanisms of the photochemistry have not yet been completely determined even though some complex theoretical models have been developed and partially confirmed experimentally. This fact has made development of a mathematical model to relate emissions of hydrocarbons, the fuel of the reaction, to the occurrence of high concentration of oxidant, the harmful constituents of smog, an elusive and difficult problem. Several complex computer models have been developed, but none has yet received universal recognition.

Location	Code	Monitored Carbon Monixide Data				Predicted Carbon Monoxide Concentration 1/
		CO (PPM)	Wind Direction	Wind Vel. (Knots)	Time	CO (PPM)
South End Runway 1R Near 101	1R	1.40	270 degrees	10	4-5 p.m.	1.70
Upper Level South Terminal 2/	US	4.10	270 degrees	14	2-3 p.m.	4.90
North Oxidation Pond, Upwind of Airport	UW	0.40	290 degrees	14	2-3 p.m.	0.50
Apron Area Airside Central Terminal	AP	1.50	310 degrees	13	3-4 p.m.	1.50
Coyote Point	CP	0.20	270 degrees	12	3-4 p.m.	0.40

1/ Wind Direction 290 degrees @ 8 knots Stability Class D

2/ The lower level terminal curbside measurements are not shown in this comparison because the dispersion model does not have the capability of simulating the effect of the overhead roadway. Predicted values for the lower level, i.e., LS were based upon scaling upwards the predicted levels for the upper level by a factor of approximately 2.0. This factor was empirically determined during the monitoring program.

EXHIBIT D-39
San Francisco International Airport
COMPARISON OF MEASURED AND
CALCULATED CARBON MONOXIDE
CONCENTRATIONS

EXHIBIT D-40
San Francisco International Airport
AIR QUALITY EVALUATION
SCENARIOS

Year	Airport Configuration	Season	Daily Operational Level	Hourly Operational Level	Meteorological Condition[1]	Description
1974	Existing	Annual " " Dec. -Feb.	Average Day " " Design Day	Average Hour " " Peak Hour	C/WNW/4.0 D/WNW/4.0 D/WNW/1.0 E/WNW/1.0	- "Typical" - "Worst-Case"
1982	No Further Development	Annual " " Dec. -Feb.	Average Day " " Design Day	Average Hour " " Peak Hour	C/WNW/4.0 D/WNW/4.0 D/WNW/1.0 E/WNW/1.0	- "Typical" - "Worst-Case"
1982	Proposed Development	Annual " " Dec. -Feb.	Average Day " " Design Day	Average Hour " " Peak Hour	C/WNW/4.0 D/WNW/4.0 D/WNW/1.0 E/WNW/1.0	- "Typical" - "Worst-Case"
1990	No Further Development	Annual " " Dec. -Feb.	Average Day " " Design Day	Average Hour " " Peak Hour	C/WNW/4.0 D/WNW/4.0 D/WNW/1.0 E/WNW/1.0	- "Typical" - "Worst-Case"
1990	Proposed Development Without BART	Annual " " Dec. -Feb.	Average Day " " Design Day	Average Hour " " Peak Hour	C/WNW/4.0 D/WNW/4.0 D/WNW/1.0 E/WNW/1.0	- "Typical" - "Worst-Case"
1990	Proposed Development With BART	Annual " " Dec. -Feb.	Average Day " " Design Day	Average Hour " " Peak Hour	C/WNW/4.0 D/WNW/4.0 D/WNW/1.0 E/WNW/1.0	- "Typical" - "Worst-Case"

[1] Meteorological conditions are given in the order of Pasquill Stability Class (C, D or E), wind direction, and wind speed in meter/sec.

- "Typical" conditions of air quality are those which exist when operational levels are equivalent to an average day[1/] and meteorological conditions are equivalent to the most probable regime which for SFIA is given as Pasquill Stability Class D (neutral), and wind from the WNW at 4.0 meter/sec. The probability of occurrence of "typical" conditions, as defined, is estimated to be approximately 50 percent of the time.

- "Worst-case" conditions of air quality are those which exist when operational levels are equivalent to the design day[2/], and meteorological conditions are equivalent to a moderately stable regime given as Pasquill Stability Class E, and wind from the WNW at 1.0 meter/sec. The probability of occurrence of "worst-case" conditions, as defined, is estimated to be less than one percent of the time, or about three days per year. The "worst-case" condition is predicted to occur during winter months (Dec. - Feb.).

(In the dispersion modeling analysis, average and peak-hour traffic levels were assumed for "typical" and "worst-case" conditions, respectively.)

Since applicable air quality standards are defined in terms of levels not to be exceeded but once per year, the "worst-case" scenario, with a probability of occurrence of three days per year, has special significance. For air quality standards to be met, predicted levels must be below applicable standards under both "typical" and "worst-case" conditions.

1/ Average day operational level is defined as average daily traffic (annual operations divided by 365) for both aircraft and ground access.

2/ Design day operational level is approximately twice that of average day operations, and is equivalent to the highest ten percentile traffic level.

5. IMPACT ASSESSMENT

The monitoring observations performed during the course of this study indicate that highest air pollution levels occur near terminal buildings, primarily near passenger loading and unloading zones, in the vicinity of airport access roads and at the airside apron areas. Thus, the impact assessment focused upon relationships between resulting air quality and traffic flow (both aircraft and motor vehicles), and parameters such as operating modes, traffic patterns, idle time, and roadway, runway, taxiway and gate utilization. Furthermore, the analysis focused upon the determination of air quality conditions at locations where people would likely be present, both on the airport and within adjacent communities.

The results of the emission inventory and dispersion modeling are presented for existing (1974) conditions, and for conditions which would likely prevail during the future years 1982 and 1990. Air quality was predicted for typical conditions (average traffic/most probable meteorology), and for most adverse conditions (design day traffic/adverse meteorology). The air quality analysis included the assessment of the effects of the proposed airport development as well as the effects of no further airport development.

The remaining sections of this appendix present the results of the air quality impact in terms of the following:

- State of California and National Ambient Air Quality Standards
- State of California "Air Quality Implementation Plans" and "Transportation Control Strategies" for critical regions

The conformance or nonconformance to the above criteria is demonstrated by the results of the emission inventory, predicted air quality concentrations, and resultant airport-related VMT.

(1) General Discussion

The federal government through the EPA has identified six major classes of pollutants in the ambient air which may, if in high enough concentration, cause detrimental effects to human health and well-being. In an effort to assure the population a healthful environment, the State of California and Federal Government has established ambient air quality standards for these six pollutants:

- Carbon monoxide
- Nonmethane hydrocarbons
- Nitrous oxides
- Oxidant
- Particulate matter
- Sulphur dioxides

Exhibit D-41, on the following page, summarizes both the State of California and NAAQS. As indicated, the State of California also has ambient air quality standards for hydrogen sulfide and lead. Hydrogen sulfide and lead are not primarily related to commercial aircraft operations. The following paragraphs succinctly describe the pollutants possibly generated at an airport.

Pollutant	Averaging Time	Ambient Air Quality Standard		
		California	Federal Primary	Federal Secondary
Carbon Monoxide	12 hr. 8 hr. 1 hr.	10 ppm (11 mg/m^3) NS 40 ppm (46 mg/m^3)	NS 9 ppm (10 mg/m^3) 35 ppm (40 mg/m^3)	Same as Primary
Nitrogen Dioxide	Annual Average 1 hr.	NS 0.25 ppm (470 mg/m^3)	0.05 ppm (100 μg/m^3) NS	Same as Primary
Hydrocarbons (Non-Methane)	3 hr. (6 to 9 a.m.)	NS	0.24 ppm (160 μg/m^3)	Same as Primary
Sulfur Dioxide	Annual Average 24 hr. 1 hr.	NS 0.04 ppm (105 μg/m^3) 0.5 ppm (1310 μg/m^3)	0.03 ppm (80 μg/m^3) 0.14 ppm (365 μg/m^3) NS	0.02 ppm (60 μg/m^3) 0.10 ppm (260 μglm^3) NS
Particulate Matter	Annual G. Mean 24 hr.	60 μg/m^3) 100 μmg/m^3)	75 μg/m^3) 260 μglm^3	60 μg/m^3) 150 μg/m^3)
Oxidant	1 hr.	0.10 ppm (200 μg/m^3)	0.08 ppm (160 μg/m^3)	Same as Primary
Lead (Particulate)	30-day Average	1.5 μg/m^3)	NS	NS
Hydrogen Sulfide	1 hr.	0.03 ppm (42 μg/m^3)	NS	NS

Notes:

1. National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health. Each state must attain the primary standards no later than three years after that state's implementation plan is approved by the Environmental Protection Agency (EPA).
2. National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Each state must attain the secondary standards within a "reasonable time" after implementation plan is approved by the EPA.
3. Federal standards, other than those based on annual averages or annual geometric means, are not to be exceeded more than once per year.

NS = No Standard

EXHIBIT D-41
San Francisco International Airport
AMBIENT AIR
QUALITY STANDARDS

- "Oxidant" - popularly known as photochemical smog - is a group of substances produced by the interaction between nitrogen dioxide and certain classes of hydrocarbons ("reactive" hydrocarbons - olefins, aromatics and aldehydes). The reaction takes place under the influence of ultraviolet rays, and is therefore promoted on warm, sunny days when ventilation is low and the requisite contaminants are present. The largest fraction of oxidant is ozone, which can cause eye irritation and can damage vegetation and certain synthetic fabrics and rubber. Oxidant contributes to visibility reduction by the formation of aerosols in the reaction.

- Hydrocarbons are also of interest to this study because jet fuel is typically odorous, such that emissions may present a serious nuisance potential. Jet fuel is relatively unreactive, and therefore contributes little to oxidant.

- Carbon monoxide is produced by the incomplete combustion of carbonaceous material, including jet fuel.

- Sulphur oxides are produced by the combustion of fuel in jet engines as well as automobiles. The gas tends to stay close to the point of emission on days of low ventilation, so that accumulations in the vicinity of airports are to be expected.

- State standards have been set for two classes of particulate matter. The smaller particulates are visibility-reducing. Jet engine exhaust includes primarily the larger type particulates, which tend to fall out more rapidly. The particulates associated with jet engine exhaust thus contribute more to local soiling problems than to visibility restriction.

- Finally, nitrogen oxides are formed by the oxidation of air (which is about 80 percent nitrogen) during high-temperature combustion; thus, the technique of high temperature combustion as a means of reducing levels of unburned hydrocarbons and particulates has the side effect of increasing emissions of nitrogen oxides, which contribute to photochemical smog, the reduction of visibility, and other adverse effects.

There are several basic assumptions necessary in the consideration of toxic effects of air contaminants. One is that various species of plants and animals will respond differently to different pollutants. Secondly, each species or population will have individuals more or less sensitive to a given concentration of the pollutant. Third, it is probable that ameliorative, neutral, and detrimental effects will result from various combinations of pollutants and other factors. For example, low levels of sulphur dioxide in the air are suspected to reduce certain plant diseases as the sulphur apparently acts as a fungicide.

Potential damages from air pollution include injury to human health; injury to wild and domestic animals; injury to agricultural, ornamental, and native plants; and damage to certain synthetic materials. A 1966 estimate of air pollution damage to agricultural plants alone in the San Francisco Bay region was $5,000,000 (4). Oxidants at concentrations below those that occur in the Bay region are known to have adverse effects on animals (both wild and domestic) and to result in discomfort to people, particularly those with respiratory difficulties. EPA estimated the national damage costs of air pollution to human health at 6.1 billion dollars for 1968, and total costs including damages to materials, vegetation, and residential property at 16.2 billion dollars for 1968; total costs for 1977 with no further control are estimated at 24.9 billion dollars (5).

Chronic as well as acute reactions may result from air pollution. Emphysema has increased ten-fold in California in the last 15 years, probably due in large part to increased air pollution. Carbon monoxide in atmospheric concentrations as low as 30 ppm may impair discrimination of time intervals; it is also dangerous to persons with heart problems even at present concentrations in the Los Angeles area. It is noted that on a nationwide basis aircraft contribute about 2 percent of the carbon monoxide emissions while motor vehicles contribute close to 70 percent (6).

(2) Detailed Results

The detailed results of the air quality analysis are presented in terms of resultant pollutant concentrations, airport-related emissions, and resultant airport-related VMT within the region. Each of these parameters are discussed separately below.

1. Pollutant Concentrations

The resultant local pollutant concentrations predicted by dispersion modeling are presented as isopleths (contour lines of equal concentrations), and are depicted on a basemap of the airport vicinity. The following twenty-four exhibits (Exhibits D-42 through D-65) present the series of isopleths which were developed. These isopleths present the following results:

- Maximum one hour concentrations of carbon monoxide (Exhibits D-42 through D-47)

- Maximum one hour concentrations of oxides of nitrogen (Exhibits D-48 through D-53)

- Maximum one hour concentrations of total hydrocarbons (Exhibits D-54 through D-59)

- Maximum twenty-four concentrations of particulates (Exhibits D-60 through D-65)

These isopleths are presented for the six scenarios previously described. The resultant concentrations, as depicted by this set of twenty-four exhibits, represent the contribution from airport-related sources, vicinity sources (non-airport related), and background. The background concentrations were determined by a method developed by the BAAPCD for the Bay region (25), and includes all significant mobile and stationary sources (not including SFIA). The isopleths represent worst possible conditions, for example, design day/peak hour traffic and adverse meteorology (moderately stable atmosphere and WNW winds at 1.0 meters/sec.).

The results of the prediction of air quality concentrations are further depicted in Exhibits D-66 through D-71. This set of exhibits presents, in tabular form, the results of predicted concentrations at selected locations on and in the near vicinity of the airport. The results presented in these six tabular exhibits are, in fact, identical to those depicted by the isopleths. However, they are shown in tabular form in order to derive a better indication of pollutant concentrations at certain "critical" locations. These locations are defined in Exhibit D-72 and are graphically presented in Exhibit D-73.

Examination of the isopleths and tabular exhibits indicate a wide variance of pollutant concentrations depending upon location. Highest pollutant values occur within the airport boundary, primarily near passenger loading and unloading zones (curbfront), adjacent active runways, near airfield apron areas, and near access roadways. The location of overall highest pollutant concentration is at curbside of the lower level terminal areas.

Further examination of the exhibits indicate a definite trend toward improved air quality in future years. For example, the resultant concentrations of the various pollutants are

EXHIBIT D-42
San Francisco International Airport
1974 CARBON MONOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
EXISTING AIRPORT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
10
6
3
1.5

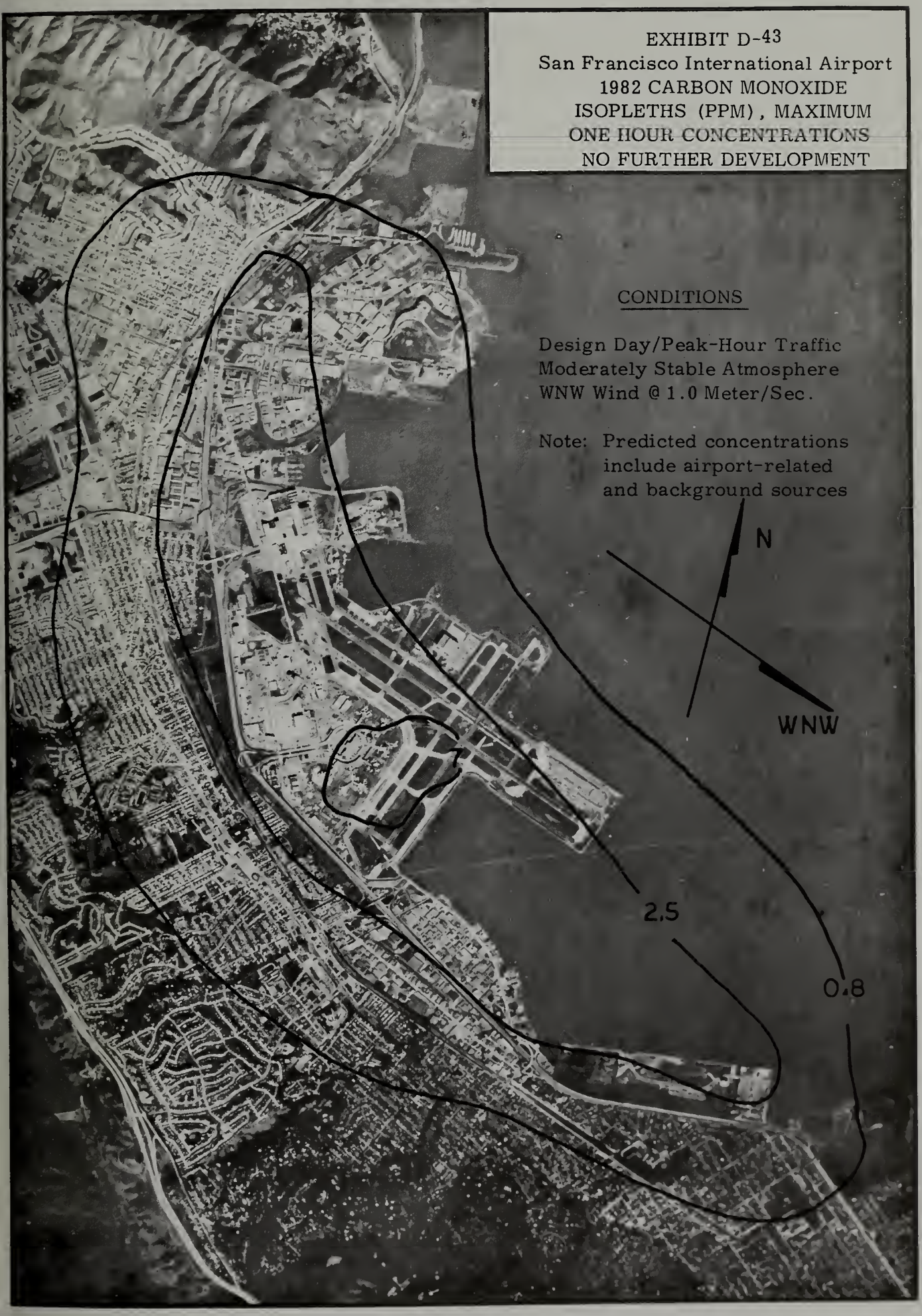


EXHIBIT D-43
San Francisco International Airport
1982 CARBON MONOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE HOUR CONCENTRATIONS
NO FURTHER DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
2.5
0.8

EXHIBIT D-44
San Francisco International Airport
1982 CARBON MONOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
6
2.5
0.8

EXHIBIT D-45
San Francisco International Airport
1990 CARBON MONOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
NO FURTHER DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
5
2
0.6

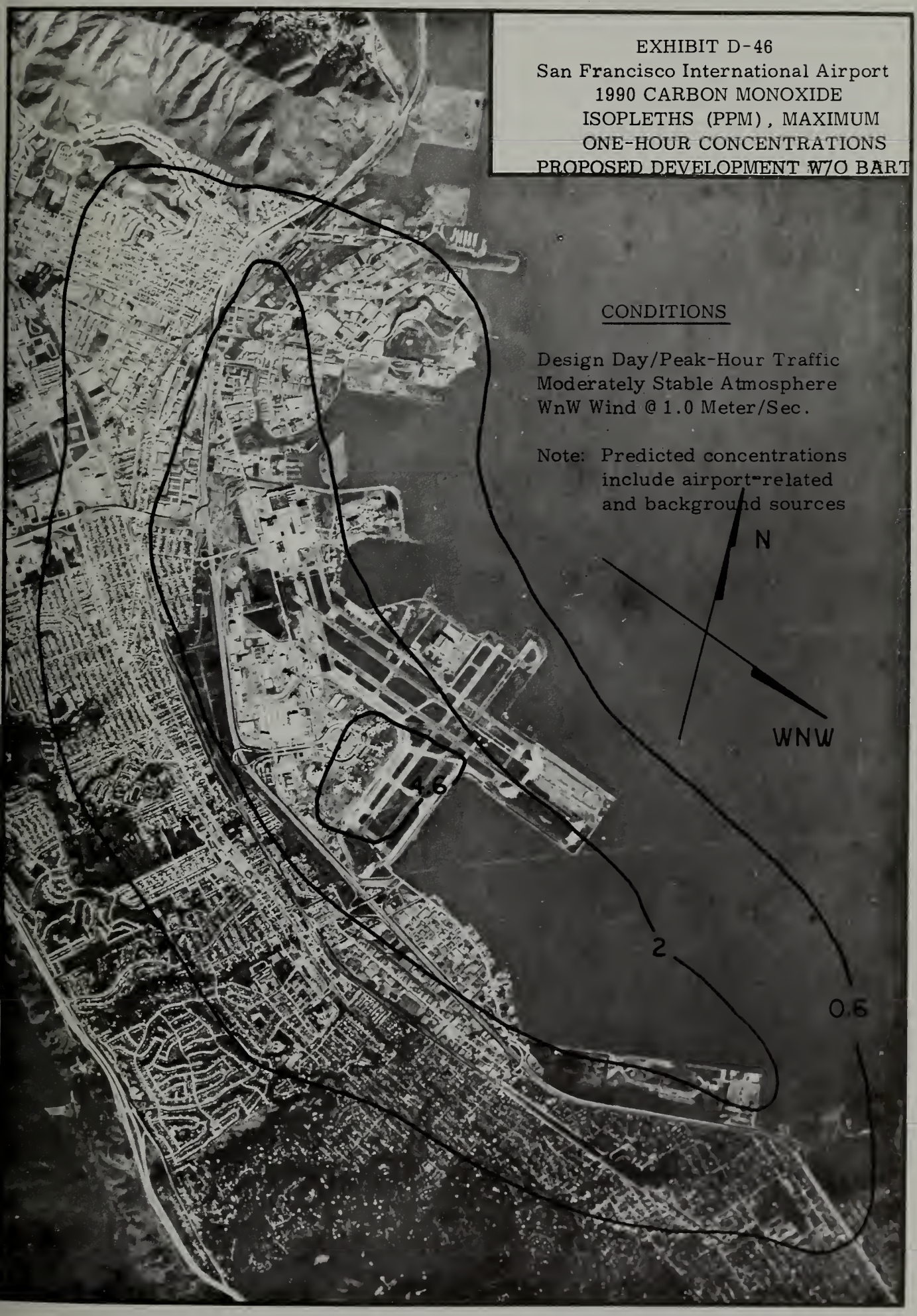


EXHIBIT D-46
San Francisco International Airport
1990 CARBON MONOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT W/O BART
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WnW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
4.6
2
0.6

EXHIBIT D-47
San Francisco International Airport
1990 CARBON MONOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT W/BART
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
4
2
0.6

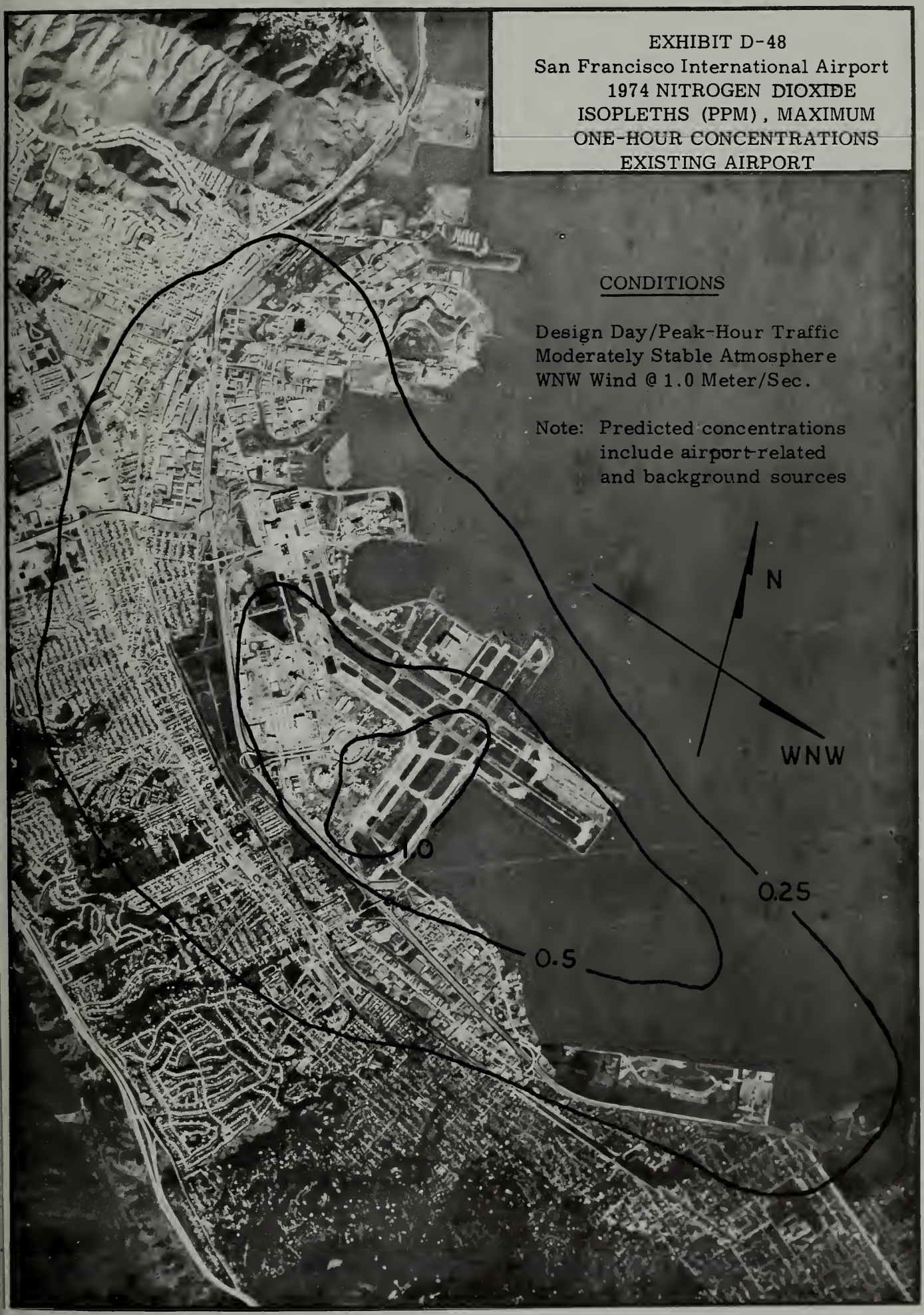


EXHIBIT D-48
San Francisco International Airport
1974 NITROGEN DIOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
EXISTING AIRPORT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
1.0
0.5
0.25

EXHIBIT D-49
San Francisco International Airport
1982 NITROGEN DIOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
NO FURTHER DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
0.8
0.10
0.25

EXHIBIT D-50
San Francisco International Airport
1982 NITROGEN DIOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
0.7
0.10
0.25

EXHIBIT D-51
San Francisco International Airport
1990 NITROGEN DIOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
NO FURTHER DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
0.5
0.04
0.10

EXHIBIT D-52
San Francisco International Airport
1990 NITROGEN DIOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT W/O BART
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
0.40
0.10
0.04

EXHIBIT D-53
San Francisco International Airport
1990 NITROGEN DIOXIDE
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT W/BART
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
0.34
0.10
0.04

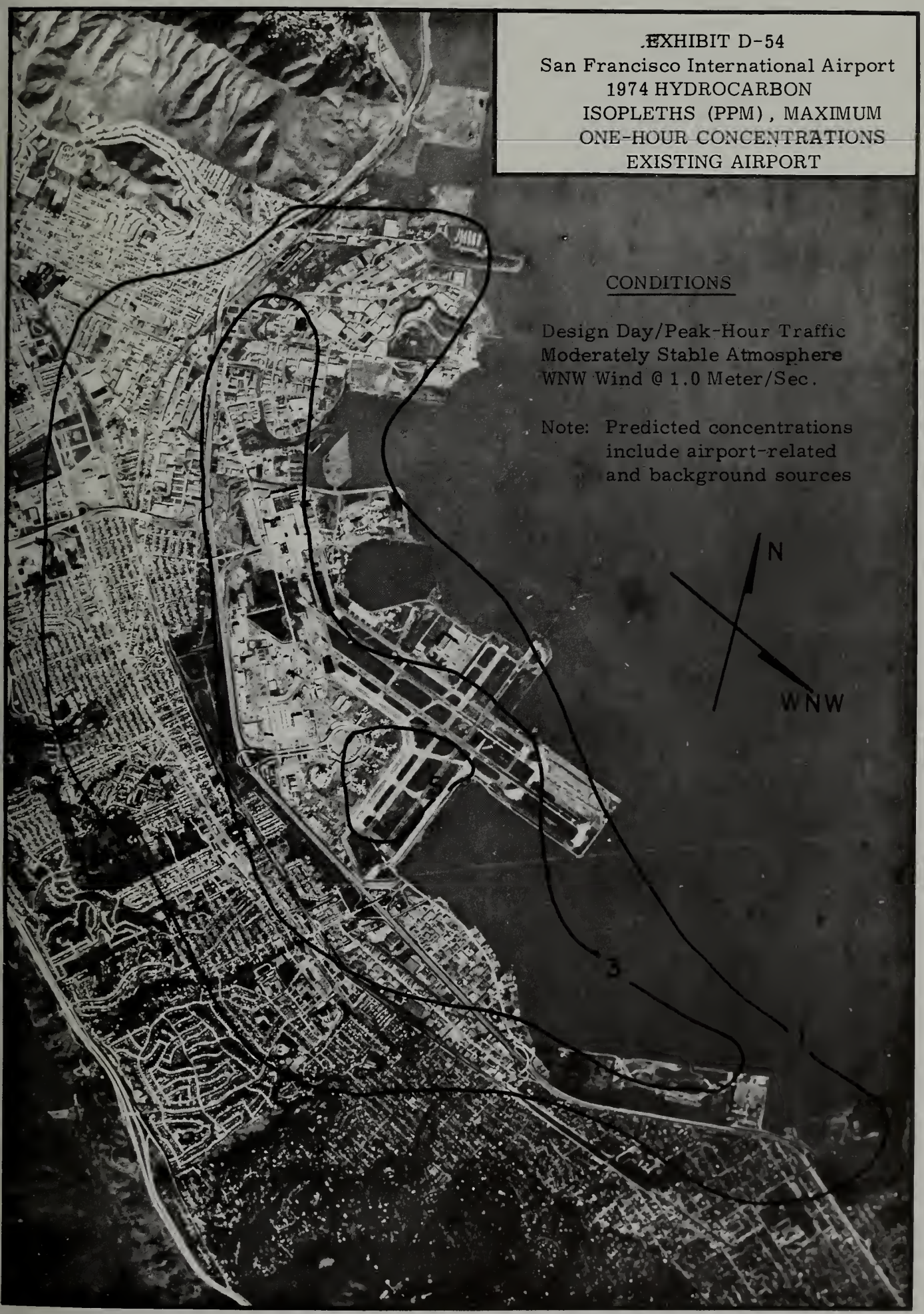


EXHIBIT D-54
San Francisco International Airport
1974 HYDROCARBON
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
EXISTING AIRPORT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
3
1

EXHIBIT D-55
San Francisco International Airport
1982 HYDROCARBON
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
NO FURTHER DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/SEc.
Note: Predicted concentrations include airport-related and background sources
N
WNW
2
0.7

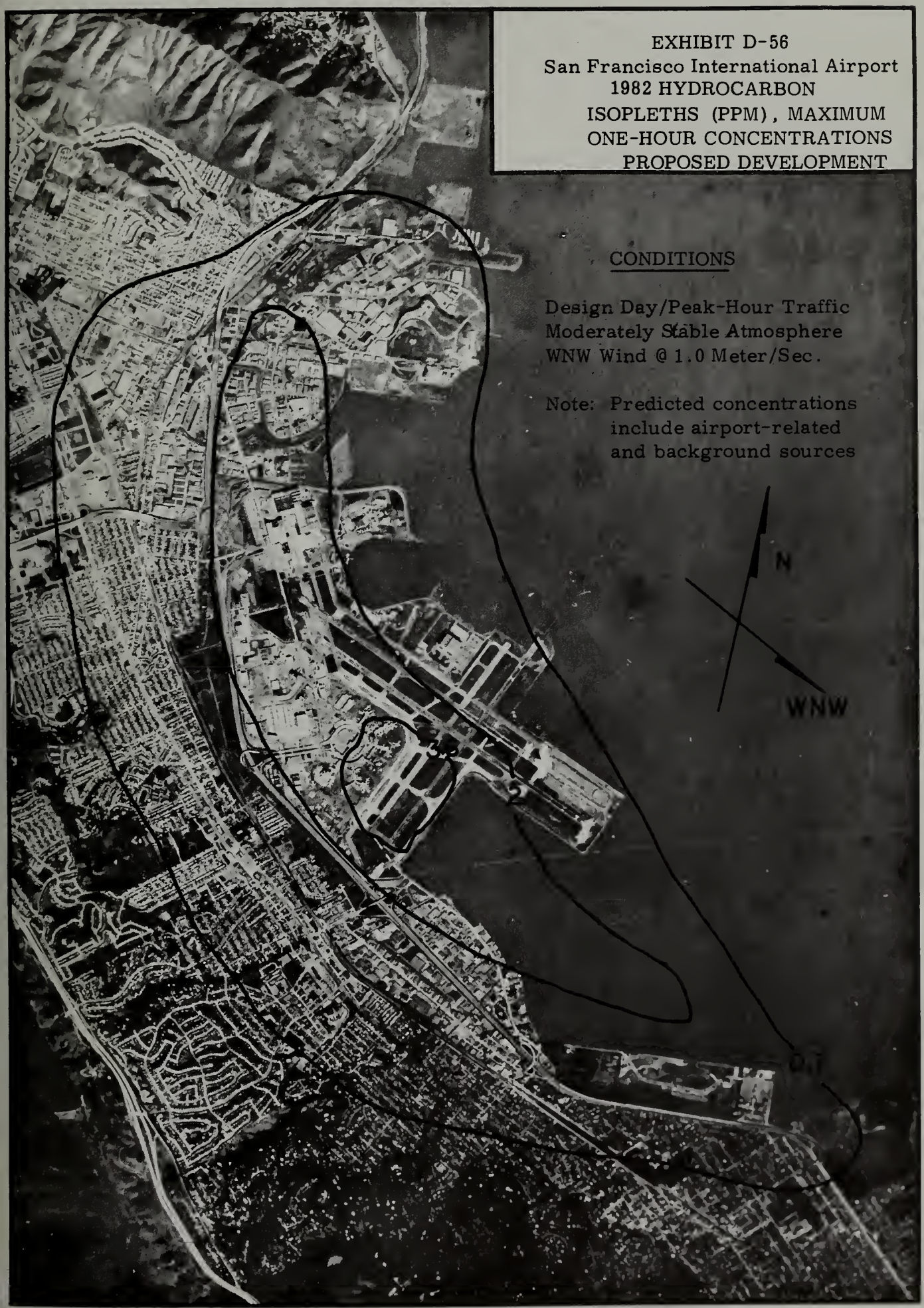


EXHIBIT D-56
San Francisco International Airport
1982 HYDROCARBON
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
3.2
0.1

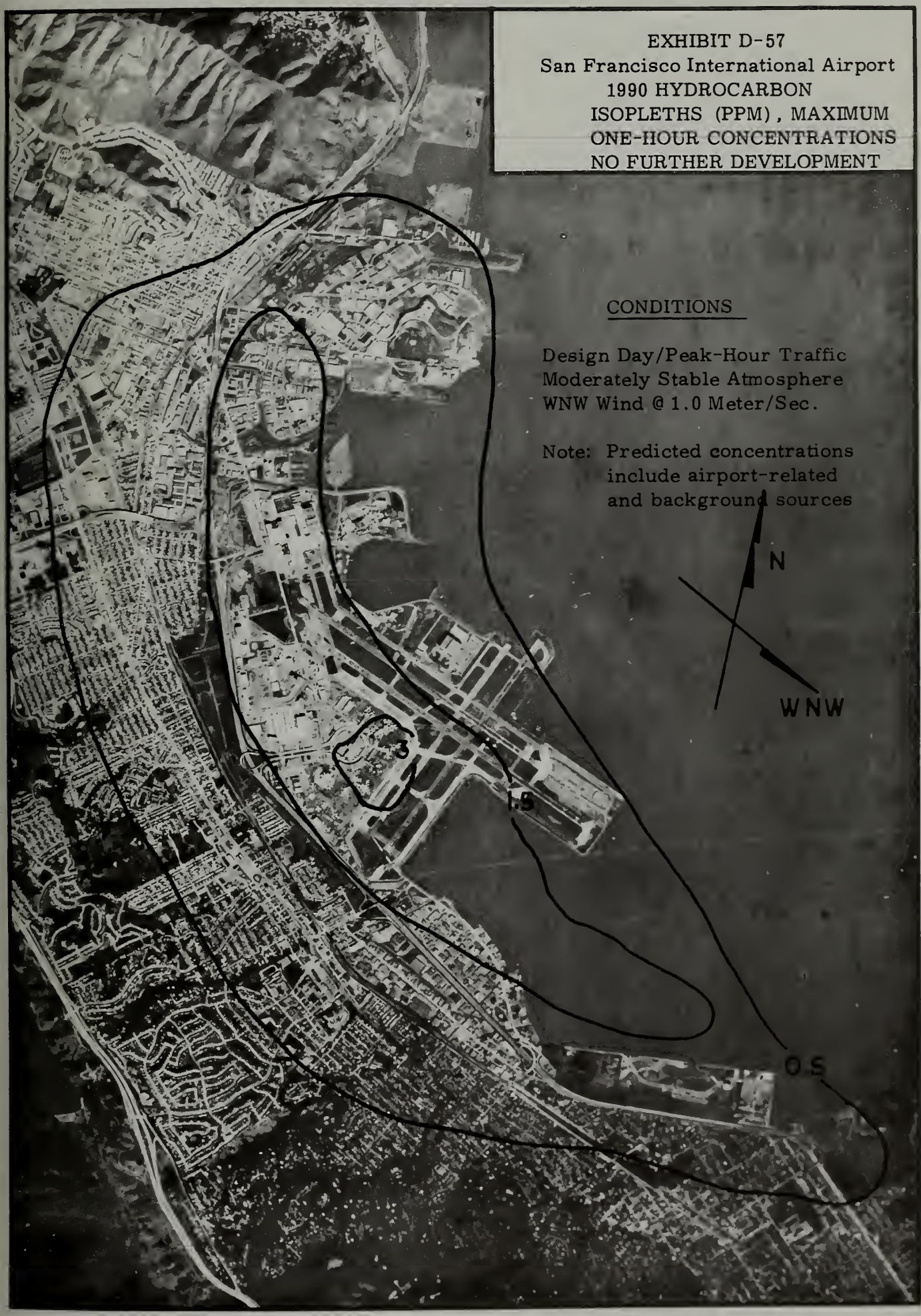


EXHIBIT D-57
San Francisco International Airport
1990 HYDROCARBON
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
NO FURTHER DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
3
1.5
0.5

EXHIBIT D-58
San Francisco International Airport
1990 HYDROCARBON
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT W/O BART
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
2.5
1.5
0.5

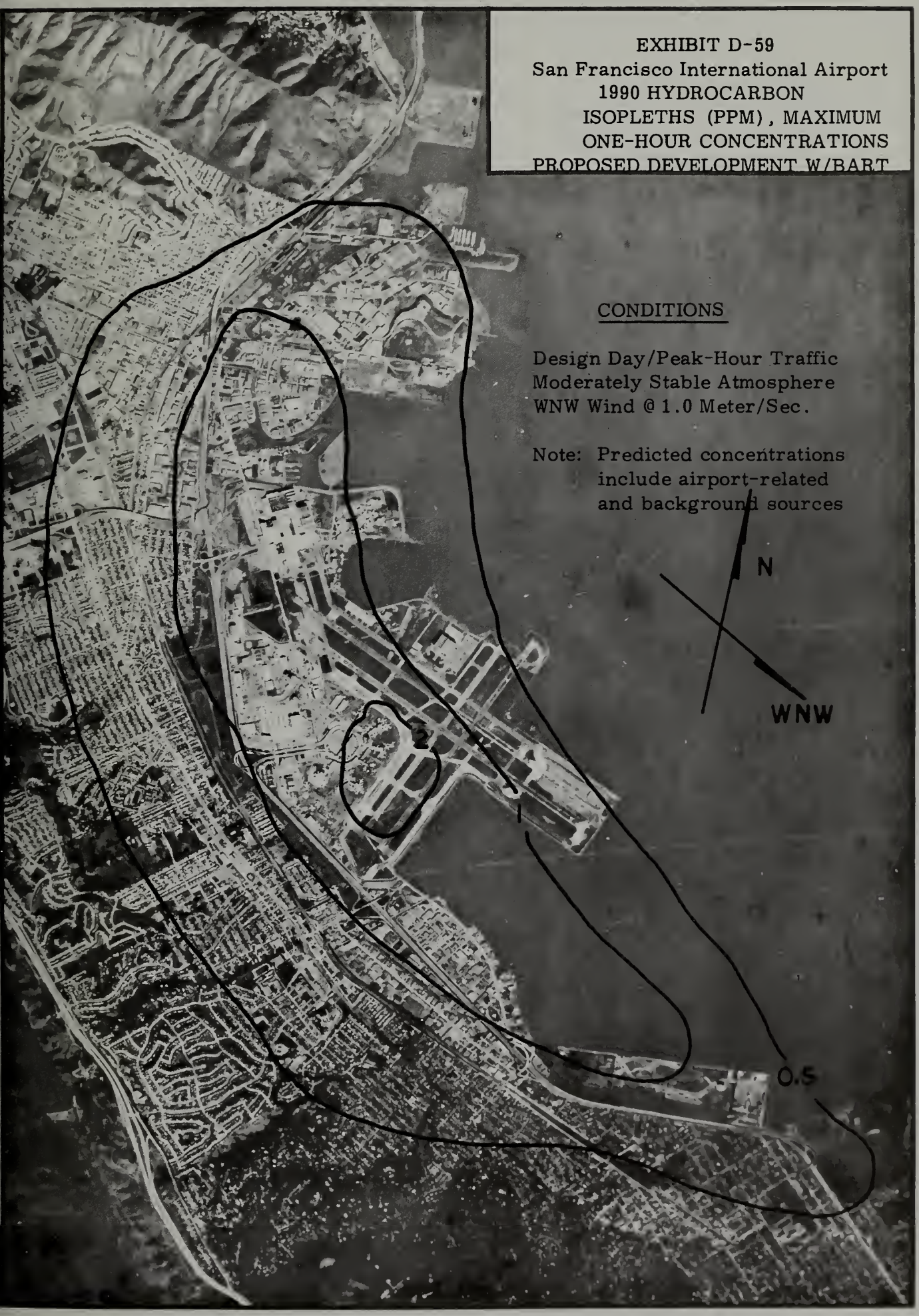


EXHIBIT D-59
San Francisco International Airport
1990 HYDROCARBON
ISOPLETHS (PPM), MAXIMUM
ONE-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT W/BART
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
0.5

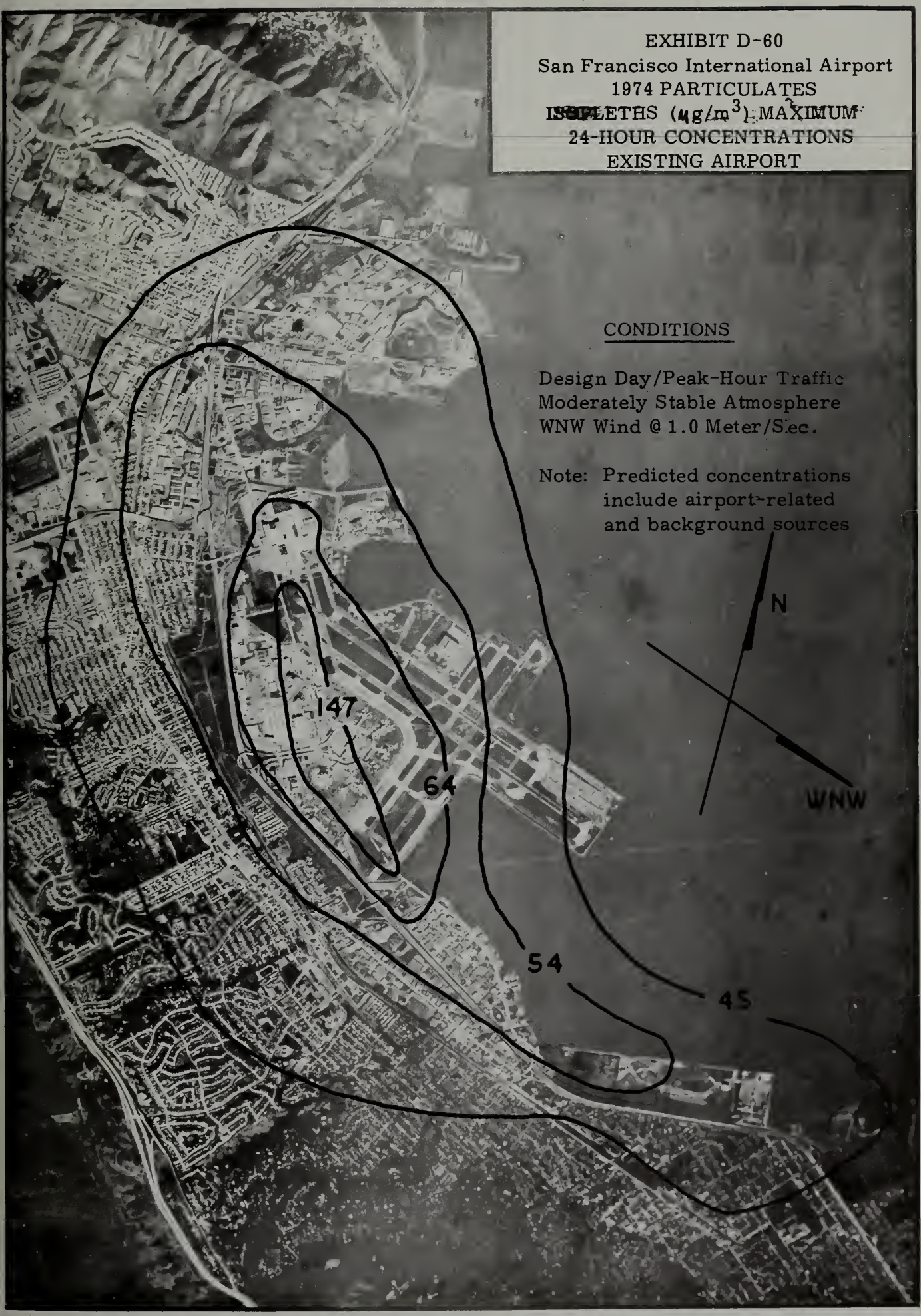


EXHIBIT D-60
San Francisco International Airport
1974 PARTICULATES
ISOPLETHS (μg/m³) MAXIMUM
24-HOUR CONCENTRATIONS
EXISTING AIRPORT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
147
64
54
45

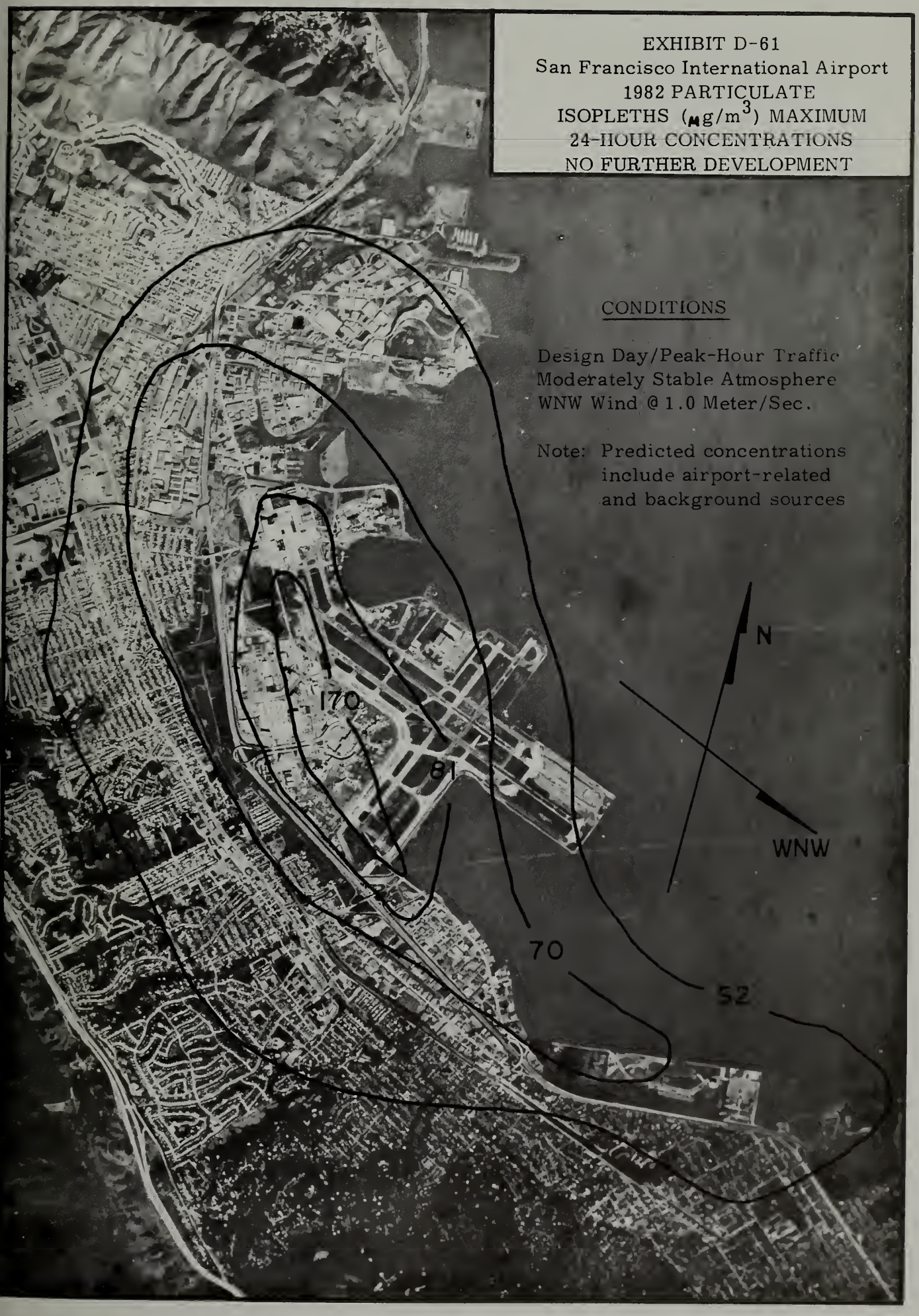


EXHIBIT D-61
San Francisco International Airport
1982 PARTICULATE
ISOPLETHS (μg/m³) MAXIMUM
24-HOUR CONCENTRATIONS
NO FURTHER DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
170
81
70
52

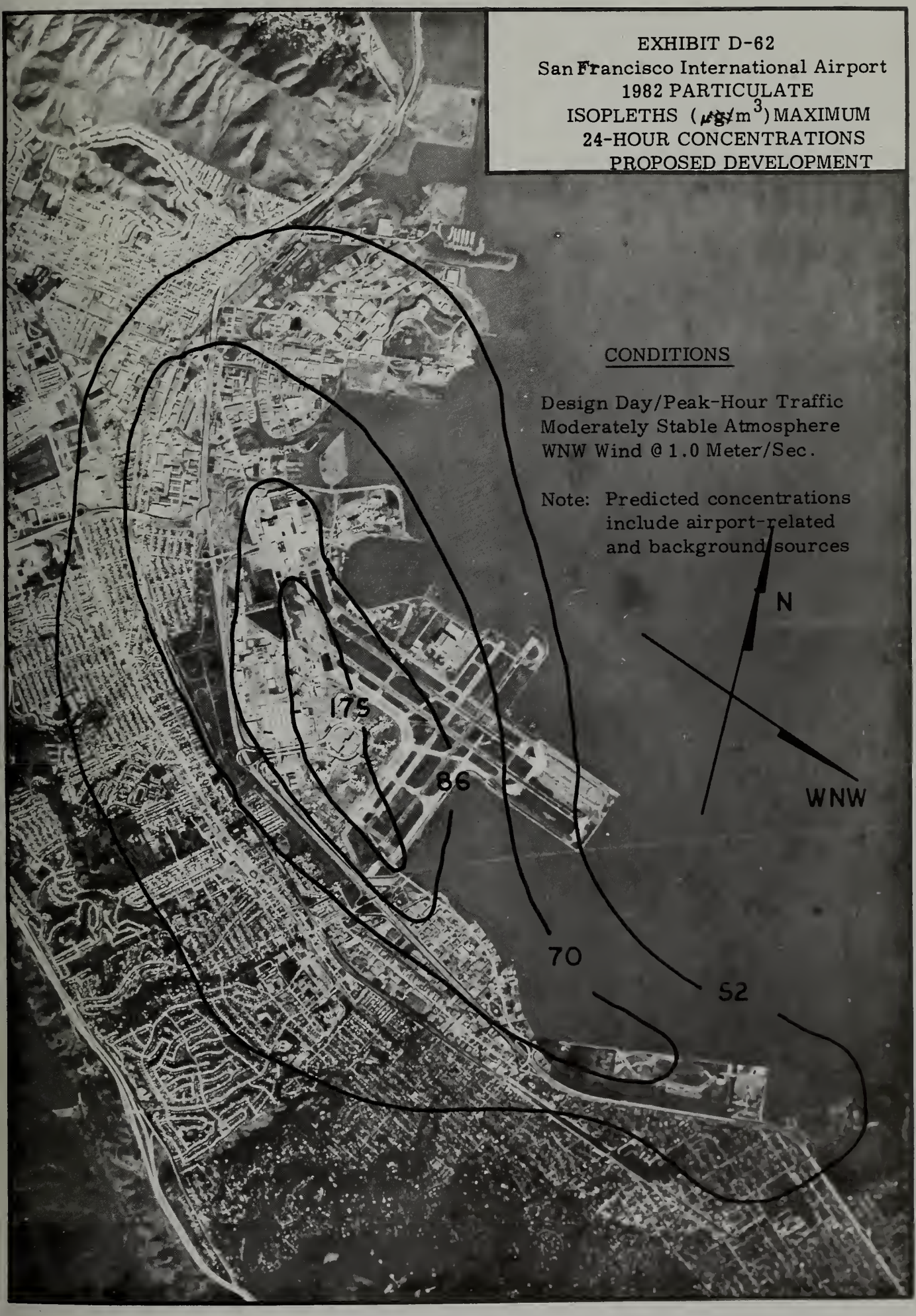


EXHIBIT D-62
San Francisco International Airport
1982 PARTICULATE
ISOPLETHS ($\mu g/m^3$) MAXIMUM
24-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
175
86
70
52

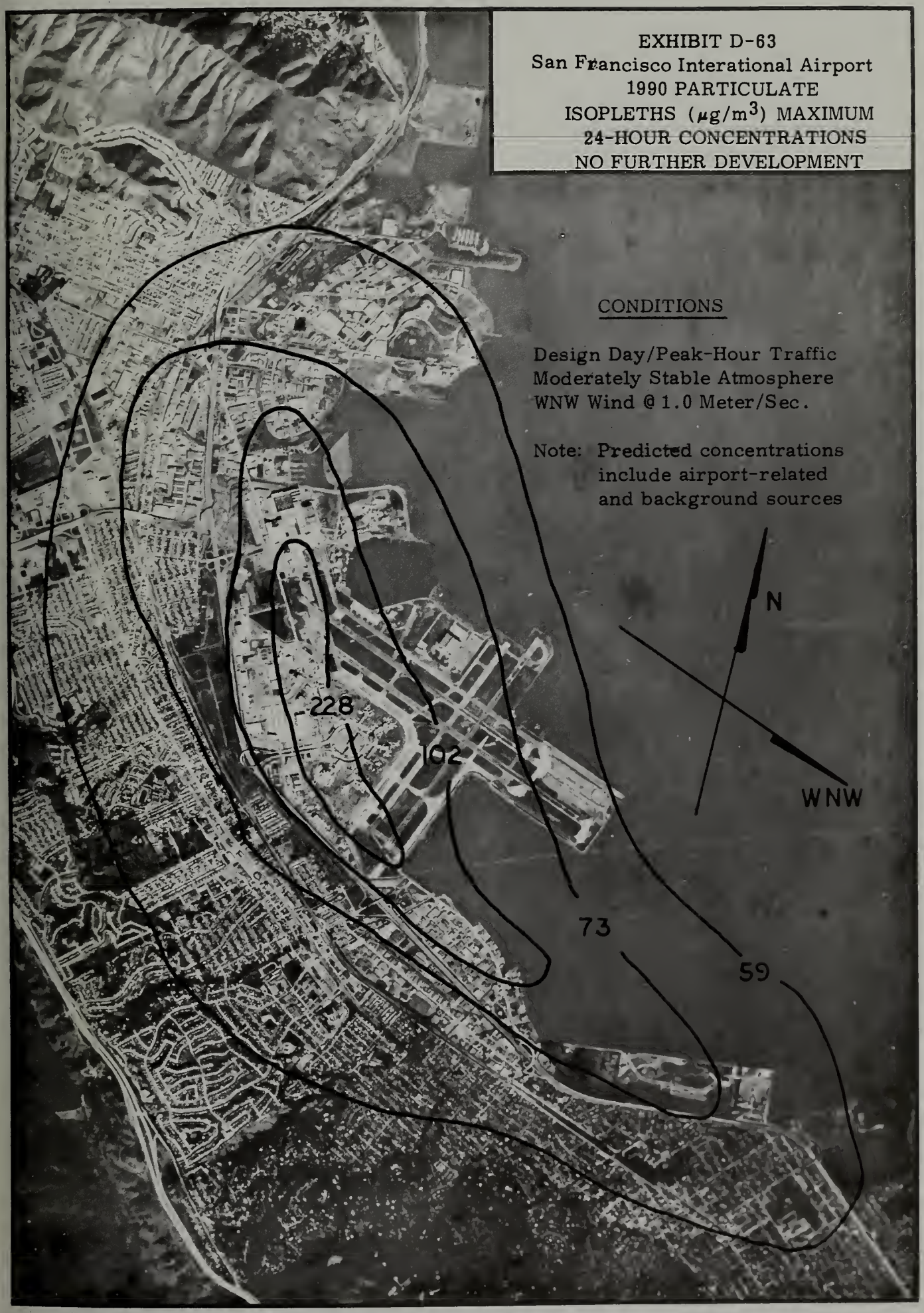


EXHIBIT D-63
San Francisco International Airport
1990 PARTICULATE
ISOPLETHS ($\mu g/m^3$) MAXIMUM
24-HOUR CONCENTRATIONS
NO FURTHER DEVELOPMENT
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
228
102
73
59

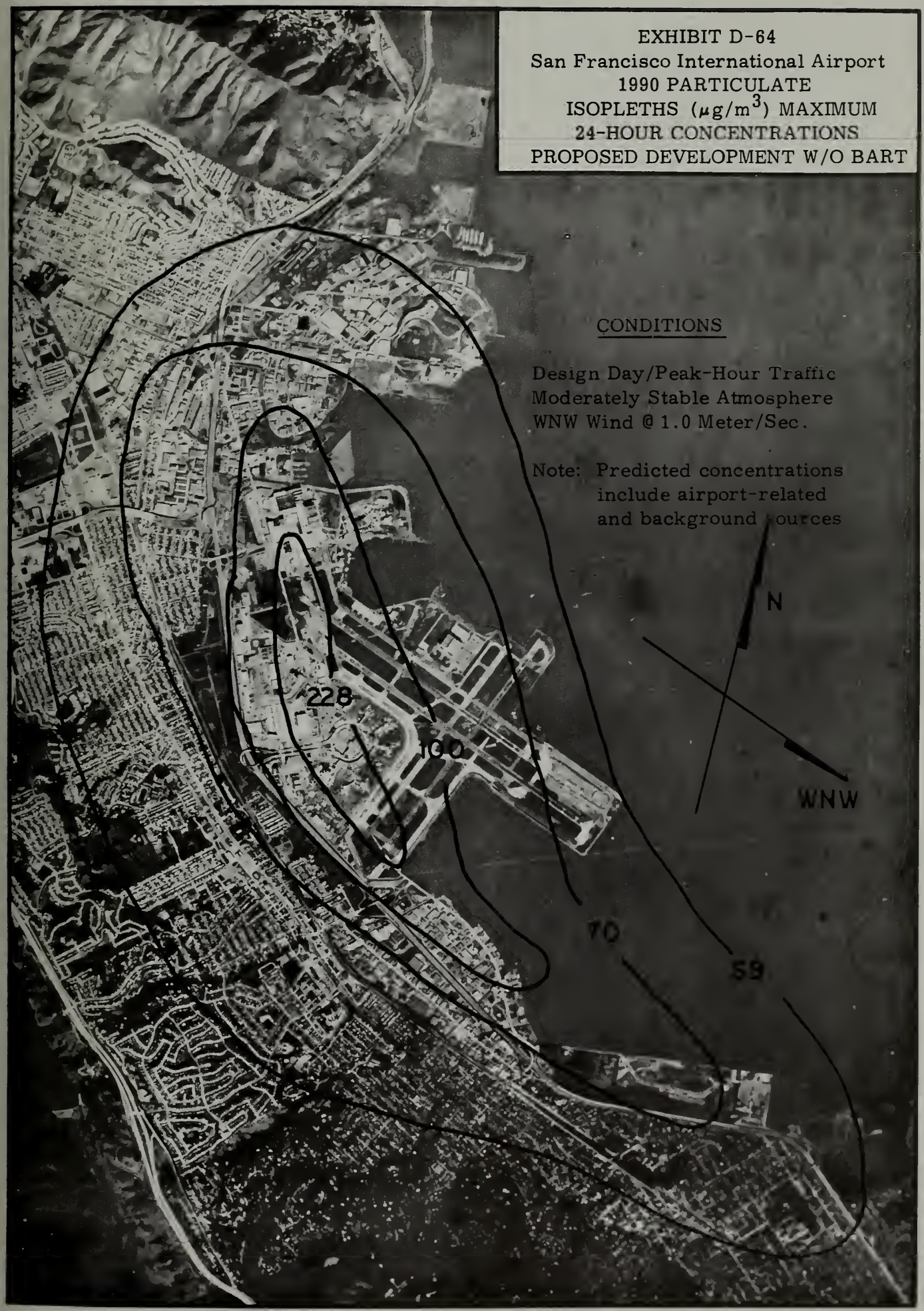


EXHIBIT D-64
San Francisco International Airport
1990 PARTICULATE
ISOPLETHS ($\mu g/m^3$) MAXIMUM
24-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT W/O BART
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
228
100
70
59

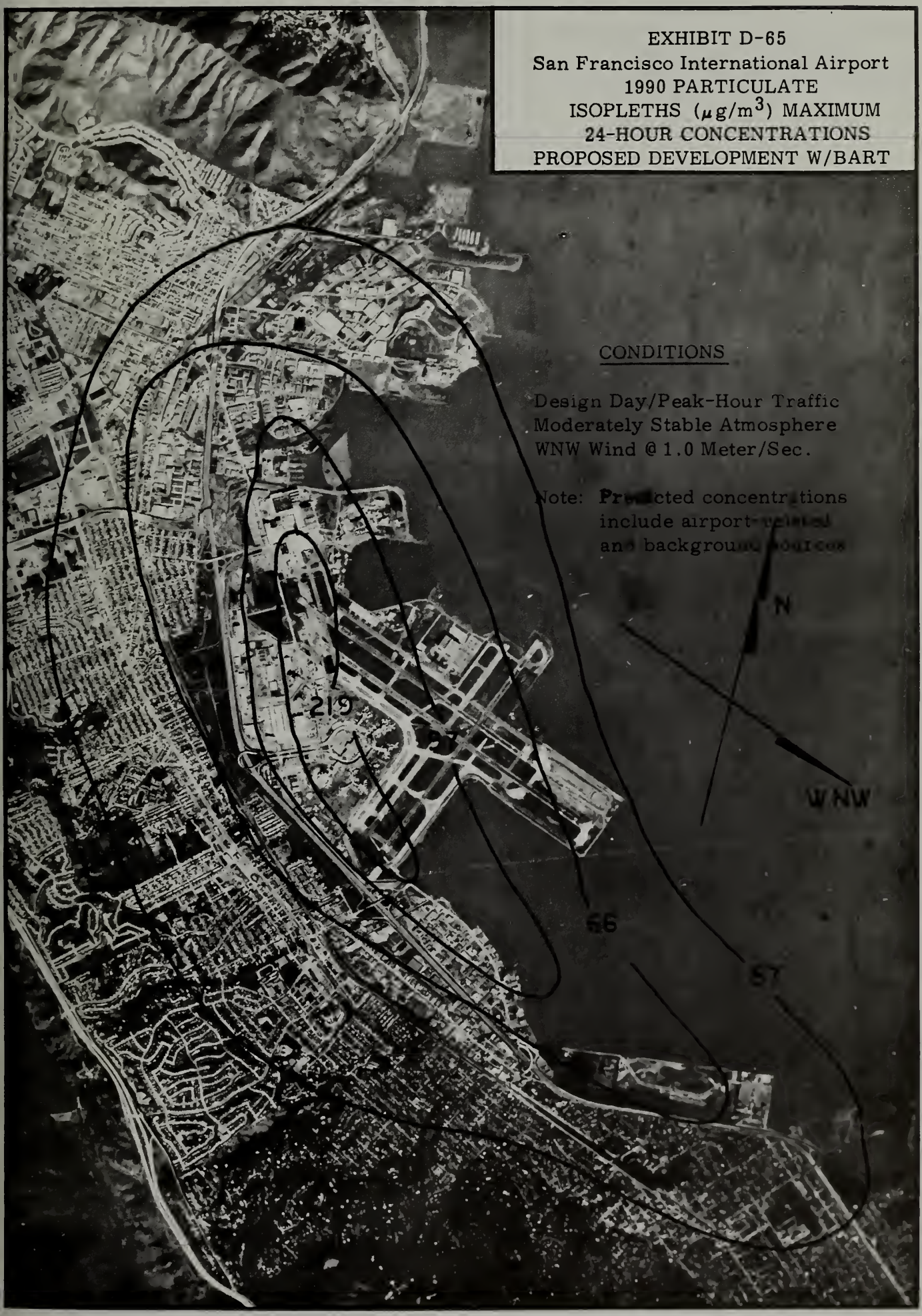


EXHIBIT D-65
San Francisco International Airport
1990 PARTICULATE
ISOPLETHS ($\mu g/m^3$) MAXIMUM
24-HOUR CONCENTRATIONS
PROPOSED DEVELOPMENT W/BART
CONDITIONS
Design Day/Peak-Hour Traffic
Moderately Stable Atmosphere
WNW Wind @ 1.0 Meter/Sec.
Note: Predicted concentrations include airport-related and background sources
N
WNW
219
66
57

Year	Airport Configuration	Condition	Predicted One-Hour Concentration Of Carbon Monoxide By Location (PPM)														
			US	UC	UN	LL	AP	ER	SF	NF	CP	SM	FC	BG	MB	SS	IR	DW
1974	Existing	Typical	4.90	2.50	0.50	11.25	1.50	0.90	0.90	1.00	0.40	0.30	0.30	0.40	0.30	0.50	1.70	0.80
		Worst Case	41.80*	20.70	3.1	62.40*	15.5	10.30	8.75	9.00	2.70	0.90	2.20	1.60	1.10	1.40	17.30	10.80
1982	No Further Dev.	Typical	2.00	1.00	0.40	4.59	0.80	0.50	0.40	0.50	0.30	0.30	0.30	0.30	0.30	0.30	1.10	0.5
		Worst Case	16.00	7.60	1.80	36.75*	6.70	4.00	3.40	3.60	1.80	0.70	1.30	0.90	0.50	0.70	9.00	7.20
	Proposed Dev.	Typical	1.00	0.60	0.30	2.30	0.50	0.50	0.40	0.50	0.30	0.30	0.30	0.30	0.30	0.30	1.10	0.45
		Worst Case	7.60	3.60	1.60	17.46	4.50	4.00	3.40	3.60	1.80	0.70	1.30	0.90	0.50	.70	9.00	6.70
1990	No Further Dev.	Typical	0.96	0.55	0.30	2.21	0.50	0.50	0.30	0.30	0.25	0.22	0.23	0.24	0.22	0.22	0.80	0.35
		Worst Case	6.90	3.20	1.10	15.85	3.60	3.60	2.80	2.80	1.40	0.50	1.00	0.68	0.39	0.40	6.10	5.40
	Proposed Dev. Without BART	Typical	0.90	0.50	0.34	2.07	0.50	0.50	0.30	0.30	0.25	0.22	0.23	0.24	0.22	0.22	0.80	0.35
		Worst Case	6.30	3.00	1.41	14.47	3.60	3.60	2.80	2.80	1.40	0.50	1.00	0.68	0.39	0.40	6.10	5.40
	Proposed Dev. With BART	Typical	0.86	0.47	0.31	1.98	0.48	0.45	0.28	0.23	0.19	0.17	0.18	0.18	0.17	0.17	0.68	0.28
		Worst Case	5.74	2.85	1.32	13.18	3.58	2.87	2.20	2.20	1.10	0.40	0.77	0.52	0.30	0.31	4.86	4.20

Notes:

1. Typical conditions are those which exist when operational levels are equivalent to an average day and meteorological conditions are equivalent to the most probable regime, which for SFIA is given as Pasquill Stability Class D (neutral) and wind from the WNW at 4.0 meters/sec.

2. Worst-case conditions are those which exist when operational levels are equivalent to the design day, and meteorological conditions are equivalent to a moderately stable regime given as Pasquill Stability Class E, and wind from the WNW at 1.0 meters/sec.

* Exceeds the 35 PPM one-hour standard for carbon monoxide.

EXHIBIT D-66
San Francisco International Airport
PREDICTED ONE-HOUR
CONCENTRATIONS OF CARBON
MONOXIDE

Year	Airport Configuration	Condition	Predicted Eight-Hour Concentration Of Carbon Monoxide By Location (PPM)														
			US	UC	UN	LL	AP	ER	SF	NF	CP	SM	FC	BG	MB	SS	IR	DW
1974	Existing	Typical	2.94	1.50	0.30	6.75	0.90	0.54	0.54	0.60	0.24	0.18	0.18	0.24	0.18	0.30	1.02	0.48
		Worst Case	25.08*	12.42*	1.86	37.44*	9.30*	6.18	5.25	5.40	1.62	0.54	1.32	0.96	0.66	0.84	10.38*	6.48
1982	No Further Dev.	Typical	1.20	0.60	0.24	2.75	0.48	0.30	0.24	0.30	0.18	0.18	0.18	0.18	0.18	0.18	0.66	0.30
		Worst Case	9.6 *	4.56	1.08	22.05*	4.02	2.40	2.04	2.16	1.08	0.42	0.78	0.94	0.30	0.42	5.40	4.32
	Proposed Dev.	Typical	0.60	0.36	0.18	1.38	0.30	0.30	0.24	0.30	0.18	0.18	0.18	0.18	0.18	0.18	0.66	0.27
		Worst Case	4.56	2.16	0.96	10.48*	2.70	2.40	2.04	2.16	1.08	0.42	0.78	0.54	0.30	0.42	5.40	4.02
1990	No Further Dev.	Typical	0.58	0.33	0.18	1.33	0.30	0.18	0.18	0.18	0.15	0.13	0.14	0.14	0.13	0.13	0.48	0.21
		Worst Case	4.41	1.92	0.66	9.51*	2.16	2.10	1.68	1.68	0.84	0.30	0.60	0.41	0.23	0.24	3.66	3.24
	Proposed Dev. Without BART	Typical	0.54	0.30	0.20	1.24	0.30	0.18	0.18	0.15	0.15	0.13	0.14	0.14	0.13	0.13	0.48	0.21
		Worst Case	3.78	1.80	0.85	8.68	2.16	2.10	1.68	1.68	0.84	0.30	0.60	0.41	0.23	0.24	3.66	3.24
	Proposed Dev. With BART	Typical	0.52	0.28	0.19	1.19	0.28	0.16	0.17	0.14	0.11	0.10	0.11	0.11	0.10	0.10	0.41	0.17
		Worst Case	3.44	1.71	0.79	7.91	2.15	1.72	1.32	1.30	0.66	0.24	0.46	0.31	0.19	0.19	2.92	2.52

Notes:

1. Typical conditions are those which exist when operational levels are equivalent to an average day and meteorological conditions are equivalent to the most probable regime which for SF/A is given as Pasquill Stability Class D (neutral) and wind from the WNW at 4.0 meters/sec.
2. Worst-case conditions are those which exist when operational levels are equivalent to the design day, and meteorological conditions are equivalent to a moderately stable regime given as Pasquill Stability Class E, and wind from the WNW at 1.0 meters/sec.

* Exceeds the 9 ppm eight-hour standard for carbon monoxide.

EXHIBIT D-67
San Francisco International Airport
PREDICTED EIGHT-HOUR
CONCENTRATIONS OF CARBON
MONOXIDE

Year	Airport Configuration	Condition	Predicted One-Hour Concentration Of Nitrogen Oxides By Location (PPM)															
			US	UC	UN	LL	AP	ER	SF	NF	CP	SM	FC	BG	MB	SS	IR	DW
1974	Existing	Typical	0.74*	0.14	0.10	1.60*	0.08	0.25	0.20	0.20	0.13	0.08	0.04	0.04	0.04	0.04	0.49*	0.56*
		Worst Case	1.44*	0.90*	0.43*	2.53*	0.41*	0.99*	0.86*	0.85*	0.59*	0.29*	0.29*	0.29*	0.28*	0.27*	1.63*	2.54*
1982	No Further Development	Typical	0.50*	0.44*	0.06	1.13*	0.05	0.07	0.04	0.06	0.05	.03	0.03	0.03	0.04	0.03	0.26*	0.49*
		Worst Case	1.12*	0.88*	0.14	1.61*	0.32*	0.50*	0.20	0.26*	0.19	0.30*	0.29*	0.15	0.22	0.16	1.10*	1.89*
	Proposed Development	Typical	0.48*	.40*	0.08	1.10*	0.04	0.05	0.04	0.06	0.04	.03	0.03	0.03	0.04	0.03	0.24	0.49*
		Worst Case	1.04*	0.72*	0.18	1.57*	0.32*	0.50*	0.20	0.35*	0.29*	0.27*	0.28*	0.15	0.11	0.16	1.10*	1.89*
1990	No Further Development	Typical	0.44*	0.19	0.05	1.00*	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.02	0.20	0.43*
		Worst Case	0.86*	0.60*	0.29*	1.18*	0.27*	0.31*	0.29*	0.29*	0.27*	0.20	0.21	0.18	0.12	0.11	1.00*	1.70*
	Proposed Dev. Without BART	Typical	0.40*	0.10	0.04	.92*	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.02	0.20	0.43*
		Worst Case	0.78*	0.56*	0.25	1.07*	0.27*	0.30*	0.28*	0.28*	0.26*	0.20	0.21	0.18	0.12	0.11	0.98*	1.68*
	Proposed Dev. With BART	Typical	0.26*	0.08	0.03	.60*	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.02	0.20	0.43*
		Worst Case	0.70*	0.48*	0.23	0.96*	0.23	0.28*	0.27*	0.27*	0.25	0.19	0.19	0.17	0.12	0.09	0.95*	1.60*

Notes:

1. Typical conditions are those which exist when operational levels are equivalent to an average day and meteorological condition are equivalent to the most probable regime, which for SFIA is given as Pasquill Stability Class D (neutral) and wind from the WNW at 4.0 meters/sec.

2. Worst-case conditions are those which exist when operational levels are equivalent to the design day, and meteorological conditions are equivalent to a moderately stable regime given as Pasquill Stability Class E, and wind from the WNW at 1.0 meters/sec.

* Exceeds the 0.25 PPM one-hour standard for Nitrogen Oxides.

EXHIBIT D-68
San Francisco International Airport
PREDICTED ONE-HOUR
CONCENTRATIONS OF NITROGEN
OXIDES

Year	Airport Configuration	Condition	Predicted One-Hour Concentration of Hydrocarbon by Location (PPM)														
			US	UC	UN	LL	AP	ER	SF	NF	CP	SM	FC	BG	MB	SS	IR	DW
1974	Existing	Typical	0.80	0.47	0.31	1.80	0.40	0.25	0.29	0.26	0.18	0.13	0.15	0.14	0.18	0.13	0.43	1.65
		Worst Case	6.16	3.26	1.74	8.46	2.52	1.98	2.70	2.92	1.26	0.91	1.87	0.90	1.32	1.20	3.38	5.65
1982	No Further Dev.	Typical	0.65	0.30	0.24	1.40	0.26	0.21	0.29	0.20	0.13	0.13	0.14	0.13	0.15	0.10	0.29	1.55
		Worst Case	2.16	1.30	1.52	4.90	1.49	1.54	1.40	1.56	1.01	0.80	0.70	0.67	0.80	0.68	1.79	4.50
	Proposed Dev.	Typical	0.63	0.25	0.29	1.44	0.24	0.20	0.19	0.20	0.13	0.13	0.14	0.13	0.15	0.13	0.27	1.55
		Worst Case	1.95	0.77	1.69	2.78	1.47	1.34	1.40	1.56	1.01	0.80	0.70	0.67	0.80	0.68	1.66	4.50
1990	No Further Dev.	Typical	0.54	0.20	0.10	1.20	0.16	0.18	0.14	0.15	0.10	0.10	0.13	0.12	0.13	0.10	0.25	1.20
		Worst Case	1.55	1.31	0.45	2.13	0.70	0.72	0.59	0.62	0.48	0.30	0.65	0.25	0.32	0.30	1.12	3.60
	Proposed Dev. Without BART	Typical	0.35	.15	0.12	0.80	0.15	0.17	0.14	0.15	0.10	0.10	0.10	0.12	0.13	0.10	0.25	1.20
		Worst Case	1.30	1.06	0.88	1.79	0.80	0.92	0.55	0.70	0.48	0.30	0.65	0.25	0.32	0.30	1.12	3.60
	Proposed Dev. With BART	Typical	0.20	0.13	0.11	0.46	0.11	0.14	0.11	0.11	0.10	0.10	0.10	0.10	0.11	0.10	0.18	0.98
		Worst Case	1.10	1.00	0.79	1.50	0.68	0.70	0.55	0.55	0.39	0.23	0.54	0.20	0.29	0.21	0.98	2.70

Notes:

1. Typical conditions are those which exist when operational levels are equivalent to an average day and meteorological conditions are equivalent to the most probable regime, which for SFIA is given as Pasquill Stability Class D (neutral) and wind from the WNW at 4.0 meters/sec.

2. Worst-case conditions are those which exist when operational levels are equivalent to the design day, and meterological conditions are equivalent to a moderately stable regime given as Pasquill Stability Class E, and wind from the WNW at 1.0 meters/sec.

3. The applicable standard for hydrocarbon is 0.24 PPM three-hour average (6 to 9 a.m.) for non-methane hydrocarbons. Values given in the total above are for total hydrocarbons. It is estimated that non-methane hydrocarbon would represent less than one-half those indicated. Violations of standards are not indicated as on previous exhibits.

4. Regarding oxidant levels, it is assumed that if resulting non-methane hydrocarbon values are less than 0.24 ppm, there will be no violation of the oxidant standard of 0.08 ppm.

EXHIBIT D-69
San Francisco International Airport
PREDICTED ONE HOUR CONCENTRATIONS OF HYDROCARBONS

Year	Airport Configuration	Condition	Predicted 24 Hour Concentration of Particulates by Location ($\mu g/m^3$)															
			US 4	UC 2	UN 50	LL	AP 12	ER 10	SF 24	NF 33	CP 5	SM 8	FC 6	BG 41	MB 36	SS 45	IR 3	DW 17
1974	Existing	Typical	42	42	41	96	42	45	48	48	41	44	41	41	41	43	78	41
		Worst Case	158*	164*	84	362*	93	110*	178*	178*	82	85	82	50	50	79	319*	84
1982	No Further Dev.	Typical	55	45	43	126*	48	50	54	52	42	54	42	43	48	59	134	55
		Worst Case	166*	184*	88	381*	100	160*	205*	205*	95	150*	94	70	75	100	550*	195*
	Proposed Dev.	Typical	52	44	42	119*	48	50	54	52	42	54	42	43	48	59	134	55
		Worst Case	152*	178*	82	349*	100	160*	205*	205*	95	150*	95	70	75	100	550*	195*
1990	No Further Dev.	Typical	63	46	66	145*	55	62	69	66	48	64	47	45	59	64	242	67
		Worst Case	335*	230*	107*	460*	212*	509*	234*	220*	140*	212*	130*	64	73	119*	850*	227*
	Proposed Dev. Without BART	Typical	64	47	63	147*	52	62	69	66	48	64	48	45	59	64	242	66
		Worst Case	280*	191*	100	385*	212*	499*	234*	220*	140*	212*	140*	84	73	119*	850*	227*
	Proposed Dev. With BART	Typical	60	45	60	139*	52	60	67	64	48	60	44	45	59	64	236	66
		Worst Case	276*	187*	100	380*	212*	487*	220*	220*	140*	198*	130*	84	73	119*	810*	221*

Notes:

1. Typical conditions are those which exist when operational levels are equivalent to an average day and meterological conditions are equivalent to the most probable regime, which for SFIA is given as Pasquill Stability Class D (neutral) and wind from the WNW at 4.0 meters/sec.

2. Worst-case conditions are those which exist when operational levels are equivalent to the design day, and meterological conditions are equivalent to a moderately stable regime given as Pasquill Stability Class E, and wind from the WNW at 1.0 meters/sec.

* Exceeds the 100 $\mu g/m^3$ 24-hour standard for particulates.

EXHIBIT D-70
San Francisco International Airport
PREDICTED 24 HOUR CONCENTRATIONS
OF PARTICULATES

Year	Airport Configuration	Condition	Predicted One-Hour Concentration of Sulfur Dioxide by Location (PPM)															
			US	UC	UN	LL	AP	ER	SF	NF	CP	SM	FC	BG	MB	SS	IR	DW
1974	Existing	Typical	.005	.003	.004	.009	.003	.002	.004	.004	.003	.003	.003	.002	.003	.002	.003	.003
		Worst Case	.059	.032	.009	.021	.022	.028	.009	.016	.007	.007	.007	.009	.005	.007	.027	.013
1982	No Further Dev.	Typical	.005	.004	.004	.009	.004	.004	.006	.006	.004	.004	.004	.003	.003	.004	.004	.003
		Worst Case	.063	.046	.038	.087	.024	.029	.010	.018	.008	.008	.008	.009	.006	.007	.029	.014
	Proposed Dev.	Typical	.005	.003	.004	.009	.004	.004	.006	.006	.004	.004	.004	.003	.003	.003	.004	.003
		Worst Case	.060	.039	.031	.070	.024	.029	.010	.018	.008	.008	.008	.009	.006	.007	.029	.014
1990	No Further Dev.	Typical	.009	.009	.008	.018	.007	.006	.007	.009	.005	.005	.005	.005	.005	.004	.005	.004
		Worst Case	.084	.087	.080	.183	.033	.031	.031	.018	.018	.019	.018	.015	.009	.014	.034	.027
	Proposed Dev. Without BART	Typical	.007	.005	.005	.114	.007	.006	.007	.009	.005	.004	.005	.006	.003	.004	.005	.004
		Worst Case	.067	.069	.062	.142	.033	.031	.031	.018	.018	.019	.018	.015	.009	.014	.034	.027
	Proposed Dev. With BART	Typical	.007	.005	.005	.011	.007	.006	.007	.009	.005	.004	.005	.005	.003	.004	.005	.004
		Worst Case	.066	.066	.024	.055	.033	.031	.031	.018	.018	.019	.018	.015	.009	.014	.034	.027

Notes:

1. Typical conditions are those which exist when operational levels are equivalent to an average day and meterological conditions are equivalent to the most probable regime, which for SFIA is given as Pasquill Stability Class D (neutral) and wind from the WNW at 4.0 meters/sec.

2. Worst-case conditions are those which exist when operational levels are equivalent to the design day, and meterological conditions are equivalent to a moderately stable regime given as Pasquill Stability Class E, and wind from the WNW at 1.0 meters/sec.

* Exceeds the 0.5 PPM one-hour standard for sulfur dioxide.

EXHIBIT D-71
San Francisco International Airport
PREDICTED ONE HOUR CONCENTRATIONS
OF SULPHUR DIOXIDE

EXHIBIT D-72
San Francisco International Airport
DEFINITION OF SELECTED LOCATIONS
FOR DETERMINATION OF AIR QUALITY

Code	Description
US	Upper Level South Terminal, Curbside
UC	Upper Level Central Terminal, Curbside
UN	Upper Level North Terminal, Curbside
LL	Lower Level Central Terminal, Curbside
AP	Apron Area, Airside
ER	Airport Entrance Roadway
SF	South Frantage Road
NF	North Frontage Road
CP	Coyote Point
SM	San Mateo
FC	Foster City
BG	Burlingame
SS	South San Francisco
MB	Millbrae
IR	South End Runway IR, Near 101
DW	Downwind of IR

EXHIBIT D-73
San Francisco International Airport
SELECTED LOCATIONS FOR
DETERMINATION OF PREDICTED
AIR QUALITY LEVELS
SS
NF
UN
AP
ER
DW
UC
LL
US
AB
IB
BG
CP
SM

approximately one-half as great in 1982 than exist today. By the year 1990, pollutant concentrations would be further reduced by approximately one-half those which would exist in 1982.

In comparing the six evaluation scenarios, the proposed airport development option results in improved air quality in comparison to existing conditions, and to those conditions which would exist if no further development takes place. The air quality conditions are improved under the proposed development primarily because of improved vehicle traffic flow and reduced idle time in the vicinity of the terminal curbfronts. This is evident when comparing the results of the predicted concentrations for locations US, UC, UN and LL for the proposed development versus no further development. With the addition of the North Terminal, ground vehicle traffic will be less concentrated at passenger loading and unloading zones due to the increase in curb frontage.

A comparison of the predicted pollutant concentrations to applicable ambient air quality standards (see Exhibit D-41), indicates some potential violation of standards. Under conditions which would exist more than 50 percent of the time (for example, "typical" conditions), the results shown on Exhibits D-66 through D-71 indicate the following:

- There would be no violation of either the one hour or eight hour carbon monoxide standards.

- There would be no violation of sulphur dioxide standards.

- The one hour nitrogen dioxide standard (0.25 ppm) would be violated under all scenarios, during 1974, 1982 and 1990, principally at on-airport locations such as at terminal curbfronts and adjacent to active runways.

- The federal standard for non-methane hydrocarbons (0.24 ppm, three hour average, 6 to 9 a.m.) would apparently be violated under all scenarios, during 1974, 1982 and 1990. These violations would occur primarily on airport.

- The California 24 hour standard for particulate matter (100 micrograms/meter^3) would not be violated in 1974. However, there would be some on-airport violations in 1982 and 1990 under all scenarios. (Since there is no projected improvement in particulate emission rates for automobiles, levels increase with time as traffic increases.)

Under most adverse conditions ("worst-case"), the results indicate the following:

- There would be no violations of sulphur dioxide standards.

- For today's conditions (1974), there would be a potential violation of the one hour carbon monoxide standard (35 ppm) at the upper South Terminal curbfront (US), and at the lower level terminal curbfront (LL). In 1982, there would be a violation at LL under the no development alternative. No other violations of this standard would occur.

- For 1974, there would be violations of the eight hour carbon monoxide standard (9 ppm) at locations US, UC, LL, AP and 1R, all on-airport locations. Under the no development alternative violations would occur in 1982 and 1990 at locations US and LL. Under the proposed development a violation at LL would occur in 1982, but no violations would occur by 1990.

- Violations of the nitrogen dioxide standard would occur under all scenarios and all years. These violations would occur principally on-airport, however, a few violations would occur off-airport such as at Coyote Point (CP), San Mateo (SM), and Foster City (FC).

- Violations of the non-methane hydrocarbon standard would apparently occur under all scenarios and all years. These violations would occur principally on-airport, however, a few violations would occur off-airport.

- Violations of the particulate matter standards would occur under all scenarios and all years. Levels would increase with time with violations occurring both on and off the airport.

It should be noted that the probability of occurrence of the most adverse conditions is very small, and is of the order of three days per year. However, since the criteria of the applicable ambient air quality standards are levels not to be exceeded but once per year, the conclusions noted above are valid ones.

Further review of the results indicates that the air quality impact on the surrounding communities is small. Where violations of ambient air quality standards occur, these violations are primarily limited to locations on the airport. Furthermore, under "typical" conditions most pollutant concentrations are well within applicable standards.

2. Emission Inventory

The value of the emission inventory is to demonstrate the contribution of the various air pollution sources to resultant air quality conditions. The results of the emission inventory are presented for the following:

- On-airport sources
  - Aircraft
  - Motor vehicles (autos, trucks and buses)
  - Service vehicles
  - Stationary
- Off-airport motor vehicles accessing the airport
- Off-airport motor vehicles not accessing the airport, but in the near vicinity

The first two parameters listed above represent the total airport-related emissions produced in the Bay region. The third parameter is included since it provides a relative indication of the contribution of unrelated airport motor vehicle traffic to the total emissions in the vicinity of the airport. This parameter is a significant input to the dispersion modeling. These parameters are more succinctly defined as follows:

- Airport-related emissions are those induced by airport-related activities, and represent the total emission load on the Bay region attributable to SFIA.

- Airport vicinity emissions affect air quality in the vicinity of the airport, but are not attributable to SFIA activities, i.e., local community traffic.

- Off-airport emissions generated by access vehicles are attributable to SFIA, but do not totally affect air quality in the vicinity of the airport since part of the activity occurs many miles from the airport. It is estimated that approximately 20 percent of these emissions affect local air quality in the vicinity of SFIA.

The results of the emission inventory for the six scenarios is presented in Exhibit D-74, following this page. This exhibit shows individual total emissions for each significant source for the five principal pollutants; carbon monoxide, total hydrocarbons, oxides of nitrogen, sulphur dioxide and particulate matter. As indicated, the on-airport emissions do not change significantly for the different scenarios with the exception of motor vehicles. For aircraft, carbon monoxide and sulphur dioxide emissions change very little, hydrocarbons and particulate emissions decrease slightly with time, and oxides of nitrogen approximately double from 1974 through 1990. Service vehicles and stationary sources contribute very little to total emissions. Both airport related and vicinity motor vehicles contribute fewer total emissions through time for all pollutants with the exception of particulates.

Exhibit D-75, following Exhibit D-74, further summarize the emission inventory. This exhibit also presents an estimate of the approximate contribution to total airport vicinity emissions of the various sources. This estimate is an indication of the effect of the various emission sources on air quality in the vicinity of SFIA. As indicated, aircraft currently contribute approximately 24 percent of total airport vicinity emissions. However, the percentage contribution of aircraft increases signficantly with time (more than 60 percent by 1990). Similarly, on-airport emissions currently contribute approximately 40 percent to total vicinity emissions. This contribution increases to more than 70 percent by 1990. On the other hand,

EXHIBIT D-74
San Francisco International Airport
EMISSION INVENTORY
FOR SIX SCENARIOS

SOURCE	POLLUTANT EMISSIONS (TONS/DAY)																							
	CARBON MONOXIDE						TOTAL HYDROCARBONS						OXIDES OF NITROGEN						SULFUR DIOXIDE						PARTICULATES					
	1974	No Dev.	Proj.	No Dev.	W/O BART Proj.	W/BART Proj.	1974	No Dev.	Proj.	No Dev.	W/O BART Proj.	W/BART Proj.	1974	No Dev.	Proj.	No Dev.	W/O BART Proj.	W/BART Proj.	1974	No Dev.	Proj	No Dev.	W/O BART Proj.	W/BART Proj.	1974	1982 No Dev.	1982 Proj.	1990 No Dev.	1990 W/O BART Proj.	1990 W/BART Proj.
AIRPORT RELATED																														
On-Airport																														
Aircraft	10.0	10.9	10.9	10.7	10.7	10.7	5.6	4.9	4.9	4.1	4.1	4.1	6.3	10.5	10.5	11.7	11.7	11.7	0.11	0.13	0.13	0.13	0.13	0.13	0.38	0.31	0.31	0.28	0.28	0.28
Motor Vehicles	11.2	3.8	2.7	2.9	2.5	2.1	1.1	0.4	0.3	0.28	0.22	0.18	1.0	0.4	0.35	0.27	0.26	0.24	0.41	0.12	0.07	0.19	0.14	0.10	0.13	0.19	0.16	0.29	0.25	0.21
Service Vehicles	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Stationary Sources	0.20	0.20	0.21	0.20	0.21	0.21	0.10	0.10	0.10	0.10	0.10	0.10	0.42	0.42	0.48	0.42	0.46	0.46	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	0.10	0.10	0.10	0.10	0.10	0.10
Total On-Airport	21.4	14.7	13.8	13.8	13.4	13.0	6.8	5.4	5.3	4.5	4.4	4.4	7.7	11.3	11.3	12.4	12.4	12.4	0.52	0.25	0.20	0.32	0.27	0.23	0.61	0.60	0.57	0.67	0.63	0.59
Off-Airport 3/																														
Access Vehicles	53.0	14.3	14.3	7.3	7.3	6.9	5.7	1.8	1.8	1.1	1.1	1.0	8.5	4.1	4.1	2.9	2.9	2.7	0.24	0.41	0.41	0.59	0.59	0.56	0.98	1.7	1.7	2.5	2.5	2.3
Total Airport Related 1/	74.4	29.0	28.1	21.1	20.7	19.9	12.5	7.2	7.1	5.6	5.5	5.4	16.2	15.4	15.4	15.3	15.3	15.1	0.76	0.66	0.61	0.91	0.86	0.79	1.5	2.3	2.3	3.2	3.1	2.9
AIRPORT VICINITY 2/																														
Motor Vehicles Not Accessing Airport, But in Vicinity	32.7	8.3	8.3	6.5	6.5	6.1	3.6	0.8	0.8	0.5	0.5	0.45	5.1	1.5	1.5	1.0	1.0	0.9	0.15	0.14	0.14	0.16	0.16	0.15	0.9	0.6	0.6	0.7	0.7	0.6

Notes: Neg. = Negligible or approximately less than 0.001 tons/day.

1/ Airport related emissions are those induced by airport related activities, and represent the total emission load on the Bay Region attributable to SFIA

2/ Airport vicinity emissions affect air quality in the vicinity of the airport, but are not attributable to SFIA activities.

3/ Off-airport emissions generated by access vehicles are attributable to SFIA, but do not totally affect air quality in the vicinity of the airport since part of the activities occur many miles from the airport.

EXHIBIT D-75

San Francisco International Airport

SUMMARY OF TOTAL EMISSIONS AND APPROXIMATE CONTRIBUTION TO TOTAL AIRPORT VICINITY EMISSIONS BY SOURCE

SOURCE	TOTAL EMISSIONS (TONS/DAY)						CONTRIBUTION TO TOTAL AIRPORT VICINITY EMISSIONS BY SOURCE (PERCENT)					
	1974	1982 No Dev.	1982 Proj.	1990 No. Dev.	1990 Proj. W/O BART	1990 Proj. W/BART	1974	1982 No Dev.	1982 Proj.	1990 No Dev.	1990 Proj. W/O BART	1990 Proj. W/BART
Airport Related												
On-Airport												
Aircraft	22.4	26.8	26.8	26.9	26.9	26.9	24.0	56.0	57.0	62.0	62.5	65.0
Motor Vehicles	13.8	4.7	3.6	3.9	3.4	2.8	15.0	9.8	7.6	9.0	7.9	6.7
Service Vehicles	0.03	0.03	0.03	0.03	0.03	0.03	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Stationary Sources	0.82	0.82	0.87	0.82	0.87	0.87	0.9	1.7	1.8	1.9	2.0	2.1
Total On-Airport	37.1	32.4	31.3	31.7	31.2	30.6	39.9	67.5	66.4	72.9	72.4	73.8
Off-Airport												
Access Vehicles	68.4	22.3	22.3	14.4	14.4	13.5	14.5	9.0	9.6	6.6	6.9	6.4
Total Airport Related	105.5	54.7	53.6	46.1	45.6	44.1	54.4	76.5	76.0	79.5	79.3	80.2
Airport Vicinity												
Motor Vehicles Not Accessing Airport, but in Vicinity	42.5	11.3	11.3	8.9	8.9	8.2	45.6	23.5	24.0	20.5	20.7	19.8
Estimated Total 1/ Airport Vicinity	93.3	48.2	47.1	43.5	43.0	41.5	100	100	100	100	100	100

Notes:

1/ Total airport vicinity emission is estimated to be equal to total on-airport emissions, airport vicinity emissions and 20 percent of the total off-airport (access vehicle) emissions.

the contribution from airport vicinity emissions decreases with time from approximately 45 percent for 1974 to approximately 25 percent by 1990. These results are due to the expected reductions in motor vehicle emissions, while at the same time very little relative improvement in aircraft emissions takes place.

Further examination of Exhibit D-75 indicates a significant reduction in total airport related emissions, from approximately 105 tons/day in 1974 to approximately 45 tons/day in 1990. This reduction in total airport related emissions has a net positive effect on improved local air quality and reduced total air pollution emitted in the Bay region.

The results of the emission inventory indicate slightly fewer total emissions under the proposed airport development option than the no development option. This result is attributable to reduced motor vehicle idle time at the terminal curbfront with the addition of the North Terminal. The alternative which assumes a BART link to the airport results in only slightly fewer total emissions than the other options. Only slight reduction in total emissions with BART is indicated since the concept has the effect of replacing, in part, the current form of mass transit (airporter bus), and does not effectively replace the use of private automobiles for airport access.

3. Vehicle Miles of Travel (VMT)

Exhibit D-76, following this page, summarizes the airport-related VMT generated within the Bay region for the six evaluation scenarios. As indicated, the airport-related VMT is directly related to total air passengers. From 1974 to 1990 air passengers at SFIA will increase twofold while VMT during the same period also will increase twofold.

The different airport configurations basically do not affect the resultant VMT, since VMT is a function of passenger demand and not airport facilities. The introduction of a BART link to SFIA would effectively reduce VMT by only approximately 5 percent.

The "Transportation Control Strategy" for the Bay region calls for significant reductions of VMT within the region (3). The forecast increased passenger demand at SFIA will result

Year	Airport Configuration	Total 1/ Passengers (MAP)	Daily Airport-Related VMT 2/		
			Off-Airport	On-Airport	Total
1974	Existing	16.2	1,807,000	162,500	1,969,500
1982	No Further Development	24.4	3,507,000	206,300	3,263,300
	Proposed Development	24.4	3,507,000	206,300	3,263,300
1990	No Further Development	31.0	4,420,000	280,200	4,700,200
	Proposed Development-Without BART	31.0	4,420,000	280,200	4,700,200
	Proposed Development-With BART	31.0	4,190,000	258,600	4,448,600

1/ MAP = Million Air Passengers, on and off

2/ VMT = Vehicles Miles of Travel

Source: BASAR Distribution and Landrum and Brown estimates

EXHIBIT D-76
San Francisco International Airport
SUMMARY OF AIRPORT
RELATED VMT

in increases in airport-related VMT, and therefore is not consistent with this strategy. However, the proposed airport development would not aggravate this problem, since increases in VMT would result with or without the airport expansion.

The RASS and subsequent regional studies of the Bay region transportation element have recommended ultimate allocation of air passenger demand at SFIA of 31 MAP in 1990. This decision has been made with consideration of the overall impacts on the region, including transportation facilities, socioeconomic and environmental. The net effect of the regional decision is an unavoidable increase of SFIA related VMT. As noted, this resultant increase is independent of the proposed airport development.

(3) Mitigating Measures

The proposed development of SFIA is designed to accommodate passenger allocations under the RASS Final Plan. The decision to assign 31 MAP to SFIA involved recognition of many environmental advantages of further expansion of SFIA over alternate sites. The SFIA Expansion Program therefore represents mitigation of the overall regional impact of air travel growth.

Specific mitigating elements related to minimizing adverse air quality impacts include the following:

- The increased curb frontage afforded with the North Terminal addition will result in improved traffic flow, less idle time, and generally less congestion. As a result, air quality conditions would be improved over that which would exist if no further development takes place.

- The terminal improvements and increased number of aircraft gates will result in reduced aircraft idle time while at apron areas. This element will also result in improved air quality over that which would exist if no further development takes place.

- The SFIA Expansion Program makes provision for a direct BART connection to facilitate transit access and reduce dependency on auto travel for passengers and employees. This element would reduce airport-related VMT, and thus reduce air contaminant emissions and improve local air quality.

Other mitigating measures include those proposed by airport management to encourage the reduction of contaminant emissions generated on the airport. These measures include enforcement of access vehicle idle times while at terminal curbfronts, reduced off-airport parking rates to encourage the use of remote parking areas, enforcement of minimizing aircraft idle times while parked at apron gates, and an air quality monitoring system to monitor carbon monoxide concentrations primarily at passenger loading and unloading zones.

(4) Summary and Conclusions

From the results of the air quality evaluations, the following conclusions can be drawn in regard to the impact of the proposed airport development on air quality:

- SFIA is a major indirect source of air pollutants in the local area. However, the evaluation indicates that the highest concentrations of pollutants are confined to the airport property in close proximity to the automobile and aircraft activity centers. The evaluation further indicates that the air quality within the communities surrounding SFIA is generally within acceptable limits.

- The proposed airport development program will not aggravate the air quality conditions at the airport or in adjacent communities. In fact, if further airport development does not take place a deterioration of local air quality will result due to increased vehicle congestion at the existing terminal curbfronts and extended aircraft idle time at apron gate areas. The addition of the North Terminal will add significantly to usable motor vehicle curb frontage, thus permitting more efficient vehicle flow, less congestion and reduced idle times. Additional aircraft gates, particularly those for wide-bodied aircraft, will permit more efficient operation at apron and taxi areas, which in turn will result in less air pollution.

- There currently are violations of State of California and National Ambient Air Quality Standards at the airport. These include violations of the one hour and eight hour carbon monoxide standards, the one hour standard for nitrogen dioxide, the three hour standard for non-methane hydrocarbons, and the one hour oxidant standard. These violations principally occur during most adverse conditions, for example, during peak traffic and worst case meterorological conditions. The probability of occurrence of these violations is of the order of three days per year. The locations where standards are being violated include terminal curbfront areas near passenger loading and unloading zones, apron areas, and adjacent active runways.

- The results of the evaluation show a clear trend toward overall improvement of local airport area air quality conditions in the 1982 and 1990 time periods which were analyzed. For example, total airport-related emissions will be reduced from approximately 105 tons per day in 1974 to approximately 45 tons per day in 1990. (The improvements are principally due to reduced emissions from motor vehicles.) As a result both on-airport and local air pollution concentrations will be reduced. If the proposed airport development takes place, no violations of the one hour or eight hour carbon monoxide standards will occur by 1990 even under most adverse conditions. On the other hand, if no further development takes place, violations of the eight hour carbon monoxide standard will occur. By the year 1990 there will still be potential violations of nitrogen dioxide, non-methane hydrocarbon, oxidant and particulate standards for both the proposed development or no development options.

REFERENCES

(1) The Potential Impact of Aircraft Emissions Upon Air Quality Northern Research and Engineering Corporation, December, 1971.

(2) Compilation of Air Pollutant Emission Factors, AP-42, Second Edition, and Supplement, .S. EPA, April, 1973 and September, 1973.

(3) Air Quality Implementation Plan Development for Critical California Regions, Prepared for U.S. EPA, by TRW, Inc., July, 1973.

(4) Wilsey and Ham, The Effect of Aviation on Physical Evnironment and Land Uses, 1971, p. VI - 25.

(5) Council on Environmental Quality, Fourth Annual Report, September, 1973, p. 78.

(6) Wilsey and Ham, op. cit. p. VI - 32.

(7) Bay Area Air Pollution Control District, Source Inventory of Air Pollution Emissions in the San Francisco Bay Area, 1973.

(8) Bay Area Air Pollution Control District, Contaminant and Weather Summary, January, 1973 through October, 1974.

(9) Bay Area Area Pollution Control District, Aviation Effect on Air Quality in the Bay Region, February, 1971.

(10) Robinson, E., 1959: Air Pollution Potential of California Coastal Climate (MS of Bay Area Air Pollution Control District).

(11) Holzworth, G. C., G. B. Bell, and G. A. DeMarrais, 1963: Temperature Inversion Summaries of U.S. Weather Bureau Radiosonde Observations in California. (MS of U.S. Weather Bureau and California Dept. of Public Health).

(12) Bay Area Air Pollution Control District, 1968: An Agricultural Burning Program Derived from Inversion Climatology in the San Francisco Bay Area, Info. Bull. 11-68 .

(13) Bay Area Air Pollution Control District, Information Bulletin, 6-15-70, 1970.

(14) Environmental Source Service Administration, Climate of California, Climatography of the United STates, 60-4, Silver Springs, Md., 1970.

(15) Duckwork, F.S., and Sandberg, J.S., "The Effect of Cities on Horizontal and Vertical Temperature Gradients," Bull. Amer. Meteorol. Soc. 35, 198-207, 1954.

(16) Regional Airport System Study, Final Plan, June, 1972.

(17) Northern Research and Engineering Corporation, loc. cit.

(18) Environmental Protection Agency, Loc. cit.

(19) Bay Area Air Pollution Control District, Lead Concentrations in the San Francisco Bay Area, 1970-1973, August, 1974.

(20) Bay Area Air Pollution Control District, Loc. cit. p. 2.

(21) Bay Area Pollution Control District, Loc. cit. p. 3.

(22) Federal Aviation Agency, "Airport Construction Controls to Prevent Air and Water Pollution," April, 1971.

(23) U.S. Environmental Protection Agency, "Requirements for Preparation, Adoption, and Submittal of Implementation Plans," Federal Register, Vol. 36 (158), August 14, 1971, p. 15495.

(24) A Sample Highway Air Pollution Model (HIWAY), U.S. EPA, June, 1973.

APPENDIX E

WATER USAGE AND WASTEWATER GENERATION

WATER USAGE AND WASTEWATER GENERATION

This appendix discusses, freshwater requirements versus available supply, and liquid waste volumes versus treatment capacities at SFIA.

1. INTRODUCTION

By the mere fact of its present, San Francisco International Airport generates a substantial requirement for freshwater and a substantial volume of wastewater and other liquid wastes. Furthermore, it is certainly true that as activity levels at SFIA rise, both its freshwater requirements and it volume of liquid waste effluent will increase also. The magnitudes of these changes are of significant and legitimate concern to the community and, therefore, they are discussed here in some detail.

However, in reading this appendix, it is imperative that one "keep his eye upon the donut, and not upon the hole." That is to say, the EIAR of which this appendix is a part focuses upon the environmental impacts of a particular expansion project at SFIA. More particularly, it seeks to identify the ways in which the SFIA area environment would differ (for better or worse) in the future as a function of the decision to proceed, or not to proceed with the proposed development program.

In general, air transportation demand at a major hub airport is influenced very little by the quality of the airport's facilities. In the main, national and local economic conditions determine the levels of demand for

air transportation. Thus, freshwater requirements and liquid waste volumes at SFIA will increase, in virtually the same way, whether or not the proposed expansion project is undertaken. It is extremely important to keep firmly in mind that these increases are not the consequences of the proposed project but rather are the by-products of a growing and prospering Bay Area.

The data used in this appendix have been supplied by the airport engineering office. They incorporate past and present studies by various contractors and consultants. Where necessary, the data supply by consultants have been revised in the light of more recent data not available at the time when the reports were prepared and other relevant material. In particular, projections have been made as a function of increased passenger traffic, for those parameters directly affected by the magnitude of the passenger traffic. For industrial wastes, the number of operations has been selected as the quantifier for projection, because it appears that industrial activity is more directly linked to the number of aircraft handled than to the number of passengers.

2. WATER REQUIREMENTS

In this section the water requirements of SFIA are reviewed based on historical data and available projections.

(1) Water Usage

In a study prepared in 1970 for the Airport Commission, Metcalf and Eddy (1) offered projections of water usage presented in the table below.

Year	Projected Water Usage Passengers Per Year	Average Water Usage (mgd)
1970	16,500,000	2.2
1975	22,500,000	4.0
1980	22,500,000	5.0

These projections implied average consumption per passenger as shown in the following table.

Projected Average Water Usage Per Passenger Handled

Year	Gallons/Passenger
1970	50
1975	65
1980	70

A large portion of this water must be attributed to the operation of support facilities, the requirements of which may not be directly related to the number of passengers. These projected increases in the per passenger usage assumed the development of facilities, which subsequently were not developed.

In fact, water usage per passenger has actually decreased as the number of passengers increased as is shown in the table below.

Actual Water Usage Per Passenger Handled

Year	Passengers/Day	Gallons/Passenger
1972	40,038	41.5
1973	42,649	40.5
1974	44,386	40.2

It thus appears that the projections of water usage have to be revised. Metcalf and Eddy (2) concurs with this conclusion. From the above results it appears conservative to project on the basis of about 40 gallons of water per passenger. The revised projections of water usage are presented in the following table.

Revised Water Usage Projections

Year	Passengers/Year	Average Water Usage (mgd)
1974	16,200,000	1.8
1982	24,000,000	2.6
1990	31,000,000	3.4

(2) Water Supply

SFIA receives its water from the San Francisco Water Department. In 1972 the average total amount of water supplied

to the City of and County of San Francisco was 251 mgd. In 1985, the capacity of the system will be about 350 mgd. During 1972, the airport consumption averaged about 1.7 mgd. or about 0.7 percent of that supplied to the City and County of San Francisco. According to these projections, the consumption by the airport should continue to be less than 1 percent of the supply.

3. WASTEWATER GENERATION

This section analyzes present and future wastewater loads and describes the present wastewater handling facilities, together with a proposed industrial wastewater treatment system.

(1) Wastewater Loads

The wastewaters generated by SFIA operations fall into three categories:

- Sanitary Wastes
- Industrial wastes
- Storm runoff

The present collection system does not differentiate between industrial wastes and storm water runoff at least in most airport areas. This situation is further addressed below.

1. Sanitary Wastes

There are three main sources of airport-related sanitary wastes:

- Wastes generated by employees and support facilities
- Wastes generated by passengers using airport facilities
- Wastes generated aboard aircraft

Exhibit E-1, on the following page, shows the average daily flows of sanitary wastes from all services for 1972 through 1974, as well as the range of the flows. Based on this data, the average sanitary waste loads per passenger are presented in the following table.

Average Sanitary Loads Per Passenger

Year	Passenger/Day	Gallons/Passenger
1972	40,038	18.5
1973	42,649	18.2
1974	44,386	20.7

This data indicate that the average sanitary waste is approximately 19 gallons per passenger. Using this figure, and assuming that all sanitary wastes loads are proportional to numbers of passengers, the projected sanitary waste loads for 1982 and 1990 are:

Average Daily Sanitary Waste Loads

Year	Passenger/Year	Average Sanitary Waste Load (mgd)
1982	24,000,000	1.1
1990	31,000,000	1.6

Exhibit E-2, following Exhibit E-1, shows the normalized variations in waste loads for the years 1972, 1973, and 1974. Over the three year period, the maximum peak day exceeded the average daily load by an average of 85 percent. Based on this value the expected maximum peak loads are:

EXHIBIT E-1

San Francisco International Airport

SANITARY WASTE FLOWS

YEAR	1972			1973			1974		
Flow / Month	Avg. Daily (mgd)	Max. Daily (mgd)	Min. Daily (mgd)	Avg. Daily (mgd)	Max. Daily (mgd)	Min. Daily (mgd)	Avg. Daily (mgd)	Max. Daily (mgd)	Min. Daily (mgd)
January	.628	.742	.489	0.566	0.852	0.025	0.791	1.385	0.593
February	.692	.859	.543	0.853	1.103	0.721	0.774	0.845	0.595
March	.748	.948	.600	0.806	0.897	0.717	0.822	1.336	0.465
April	.684	.881	.509	0.729	0.864	0.545	0.958	1.394	0.794
May	.708	.831	.556	0.742	0.845	0.515	0.954	1.115	0.616
June	.737	.890	.576	0.818	0.910	0.689	0.996	1.239	0.791
July	.822	.929	.714	0.792	1.123	0.647	0.931	1.088	0.759
August	.837	.966	.673	0.827	0.943	0.679	0.938	1.154	0.605
September	.779	.921	.622	0.717	0.800	0.525	0.918	1.070	0.707
October	.834	1.288	.399	0.808	1.153	0.677	0.968	1.190	0.770
November	.829	1.179	.648	0.857	.578	0.688	0.908	1.213	0.815
December	.650	.831	.495	0.819	1.217	0.585	0.958	1.652	0.442
Annual Average	.745	.938	.568	0.778	1.024	0.579	0.923	1.232	0.662

Source: SFIA Engineers

EXHIBIT E-2

San Francisco International Airport

NORMALIZED SANITARY WASTE FLOWS

YEAR	1972			1973			1974		
Flow / Month	Avg. Daily (mgd)	Max. Daily (mgd)	Min. Daily (mgd)	Avg. Daily (mgd)	Max. Daily (mgd)	Min. Daily (mgd)	Avg. Daily (mgd)	Max. Daily (mgd)	Min. Daily (mgd)
January	.843	.999	.658	.728	1.095	.032	.858	1.513	.643
February	.930	1.152	.730	1.097	1.420	.929	.838	1.022	.644
March	.999	1.271	.805	1.037	1.153	.923	1.000	1.445	.505
April	.919	1.180	.793	.937	1.110	.698	1.038	1.510	.858
May	.952	1.130	.754	.957	1.085	.663	1.034	1.207	.668
June	.990	1.194	.773	1.051	1.168	.898	1.029	1.340	.857
July	1.103	1.243	.970	1.020	1.445	.833	1.077	1.175	.823
August	1.125	1.295	.904	1.064	1.210	.863	1.080	1.250	.705
September	1.045	1.236	.835	.923	1.030	.676	.993	1.158	.767
October	1.120	1.730	.537	1.039	1.480	.860	1.035	1.287	.835
November	1.112	1.582	.870	1.103	2.010	.808	.983	1.315	.883
December	.873	1.116	.665	1.052	1.564	.753	1.038	1.790	.478
Annual Average		1.258	1.763		1.315	.745		1.335	.717

Source: Landrum and Brown estimates based on Exhibit E-1

Estimated Peak Sanitary Waste Loads

Year	Peak Sanitary Waste Load (mgd)
1982	2.0
1990	3.0

2. Industrial Wastewaters

Industrial wastewaters are generated primarily by the maintenance and support facilities. The principal sources of wastewaters are:

- Maintenance operations
- Aircraft washing
- Automobile washing by rental companies

During 1973 when there were 262,276 air carrier operations, the average industrial wastewater flow was estimated by Consoer and Townsend to be about 1.1 mgd. including infiltration (3). Industrial activity at the airport is dominated by the general aircraft maintenance facility of a major airline which according to a report prepared by Consoer and Townsend (4) represents 61 percent of industrial wastewaters generated at SFIA[1/]. Although the growth of this facility is not directly related to the growth of SFIA, but rather to the growth of one airline, a good index of growth for this facility is the increase in operations at SFIA, since this would reflect more closely the trend toward larger capacity aircraft, and the eventual fleet composition changes. Another major source of industrial wastewater is aircraft washing operations which are also linked to the number of operations. Automobile washing by the rental companies is said to represent over 1,000 cars per day. This activity is directly linked to the originating and terminating passenger traffic. Assuming about 50 gallons per day, this activity would represent only about 0.05 to 0.1 mgd. and thus no more than about 8 percent of the total industrial usage under peak conditions.

1/ This figure represents the percentage contribution estimated for dry weather conditions.

Assuming that industrial waste flows are proportional to number of operations, the projected industrial waste flows for the planning year are as shown in the table below.

Projected Industrial Waste Flows

Year	Airline Operations	Industrial Waste Flows (mgd)
1974	287,490	1.2
1982	321,130	1.3
1990	314,830	1.3

Exhibit E-3, on the following page, presents the water quality characteristics of the industrial wastewater.

3. Storm Runoff

The planned expansion of the airport to accommodate the large number of passengers would not significantly alter the runoff conditions. Only minimal additional paving is anticipated over the conditions existing in 1974. Thus, it is felt that general runoff will not be significantly different from what it is today. The figures for estimated storm runoffs for industrial areas are presented in Exhibit E-4, following Exhibit E-3. Using similar figures for the airport, with a total drainage area estimated at approximately 1,500 acres and an overall runoff coefficient of 80 percent, the estimated total runoffs are given as follows:

Estimated Overall Storm Runoff

Duration of Peak Rainfall	Runoff (mgd)
30 min.	12.2
2 hrs.	22.6
24 hrs.	71.5

EXHIBIT E-3

San Francisco International Airport

CHARACTERISTICS OF INDUSTRIAL WASTEWATERS

Parameters	Combined Industrial Waste Water	
	Average	Maximum
pH (Unit)	6 - 8	4 - 9
Suspended Solids	175	-
Volatile Suspended Solids	70	-
Total Solids	5500	-
Total Volatile Solids	960	-
Ammonia (as N)	ND (2)	-
Turbidity (jtu)	60	-
BOD	100	233
COD	300	1280
Arsenic	<0.02	-
Lead	0.25	0.74
Silver	0.02	0.08
Mercury	0.0013	0.0018
Cadmium	0.15	0.16
Chromium	0.65	0.90
Copper	0.20	0.81
Nickel	0.65	1.40
Zinc	0.30	0.70
Grease	50	596
Cyanide	<0.1	.012
Phenols	0.5	5.0
MBAS	6.0	-
Chlorinated Hydrocarbon	0.00018	-

(1) All units are in mg/l unless otherwise indicated.
(2) Non-Detectable

Source: Reference (3)

EXHIBIT E-4

San Francisco International Airport

STORM RUNOFF ESTIMATES

RAINFALL DATA

Average Annual Rainfall 18-20 inches/year
2 Year Recurrence Interval

Duration of Peak	Precipitation During Peak Period		
	Total	Average Rate	Runoff Coefficient
30 min.	.38 in.	.760 in./hr.	85%
2 hrs.	.70 in.	.350 in./hr.	85%
24 hrs.	2.20 in.	0.92 in./hr.	85%

INDUSTRIAL AREA DRAINING TO SOUTH POND

Area 300 Acres

Duration of Peak	Total Runoff During Peak Period	
	Acre Ft.	MG
30 min.	8.1	2.6
2 hrs.	14.9	4.8
24 hrs.	46.8	15.2

INDUSTRIAL AREA DRAINING TO NORTH POND
(Excluding Northeast Industrial Area)

Area 290 Acres

Duration of Peak	Total Runoff During Peak Period	
	Acre Ft.	MG
30 min.	7.8	2.6
2 hrs.	14.4	4.7
24 hrs.	45.2	14.7

Source Reference (4)

(2) Wastewater Handling Facilities

This section describes the present wastewater transmission systems, the present sanitary waste treatment plant and the present and proposed industrial waste treatment systems.

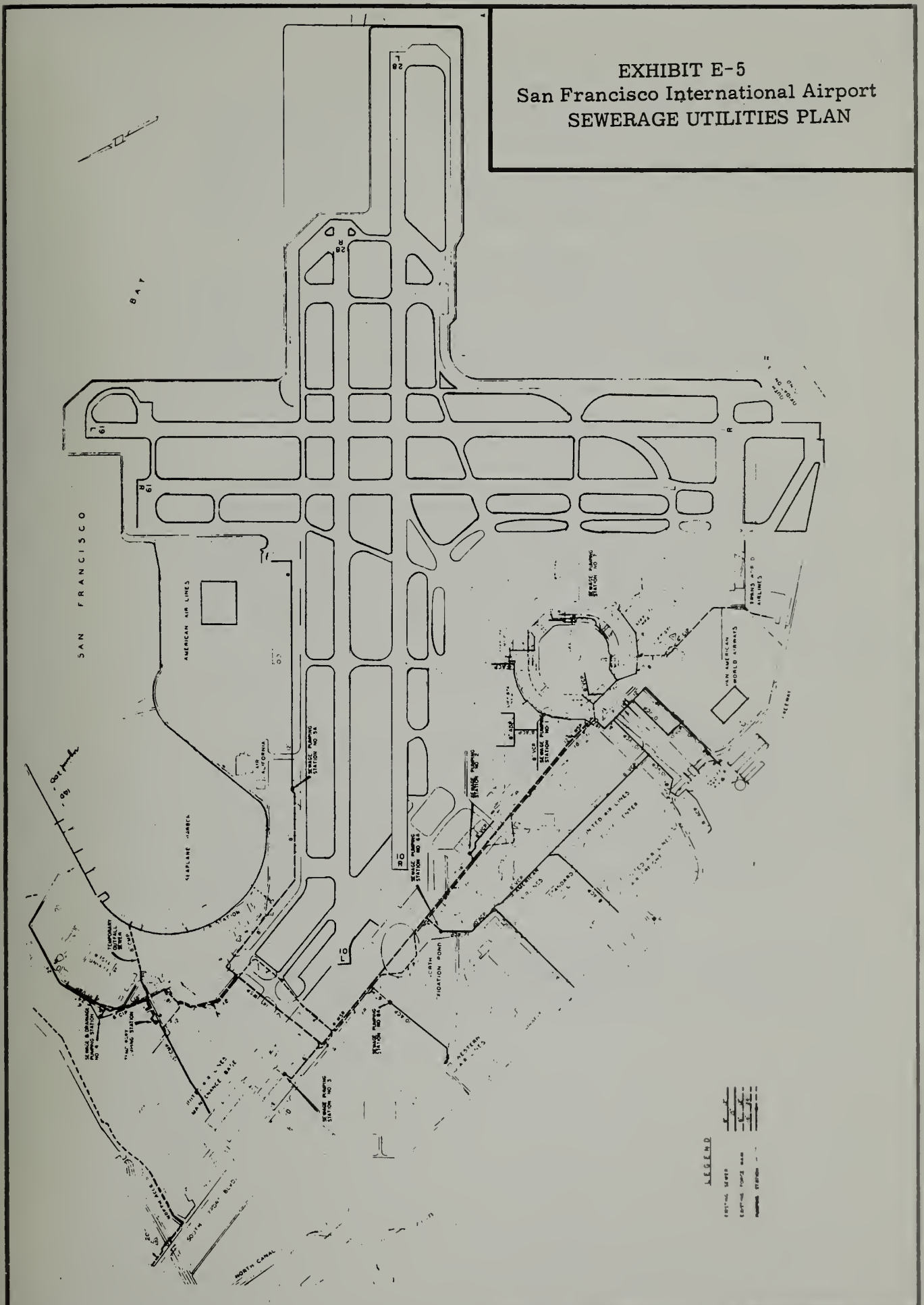
1. Sanitary Sewerage System

The sanitary sewerage system at SFIA consists of a number of gravity collection sewers, pumping stations, and a common force main connected to the sanitary sewage treatment plant. This system is depicted on Exhibit E-5, following this page. The gravity sewers serve local areas and discharge to the pumping stations. These stations, in turn, pump the sewage through branch force mains into a primary 14-inch force main traversing the property from the main entrance road to the sanitary sewage treatment plant. This system serves the total present SFIA development.

The disposal of sanitary wastes from aircraft arriving at San Francisco poses a problem to current airport sanitary waste discharges. Present day aircraft use recirculating chemical toilets which use very little water. Under standard procedures, these toilets are drained into tank trucks, and the wastes are then delivered to receiving stations to be discharged to a sewer. However, part of these wastes may be discharged into the industrial storm water network. This may account for the reported presence of fecal coliforms in the industrial storm water wastes discharged to San Francisco Bay.

An additional problem with the sewer system is that of some dislocations and misalignment caused by settling of the airport fill. This results in some areas having flat or adverse slopes which inhibit flow; however, no major problems have yet occurred and no serious problem is anticipated for the foreseeable future. Cleaning of some individual section may be required from time to time.

EXHIBIT E-5
San Francisco International Airport
SEWERAGE UTILITIES PLAN



Source: SFIA Engineers

A secondary activated sludge treatment facility has been in operation since August 1970 at SFIA. Exhibit E-6, on the following page, presents an architectural rendering of the facility. Exhibit E-7, following Exhibit E-6, shows the flow diagram of the treatment plant. The basic design criteria are given in Exhibit E-8, following Exhibit E-7.

As can be seen from the flow diagram, the plant is a typical activated sludge treatment facility with anaerobic sludge digestion followed by vacuum filtration. The treated effluent is presently being discharged to the joint South San Francisco-San Bruno outfall which in turn discharges to the San Francisco Bay about one mile offshore.

2. Present Industrial Waste Transmission System

At present, industrial wastewaters discharge to the storm drainage network. This network is presented in Exhibit E-9, following Exhibit E-8. The drainage system is a complex network of gravel subdrains, surface catchbasins and drainage pipelines and canals. The system carries wastewater either to Drainage Pumping Station No. 1 at the south end of the airport or to Drainage Pumping Station No. 2 near the north end of the airport. Numerous peripheral pipes drain the outer runways and taxiways directly to the Bay.

The southern portion of the system drains the terminal, all tenant properties south of the main entrance road, and the southern half of the runways. The major conduits discharge to the South Airport Canal. The dry weather flow discharged to the canal is pumped into the South Oxidation Pond for treatment of industrial wastes. During wet weather the excess flow in the canal is pumped to the Bay by Drainage Pumping Station No. 1.

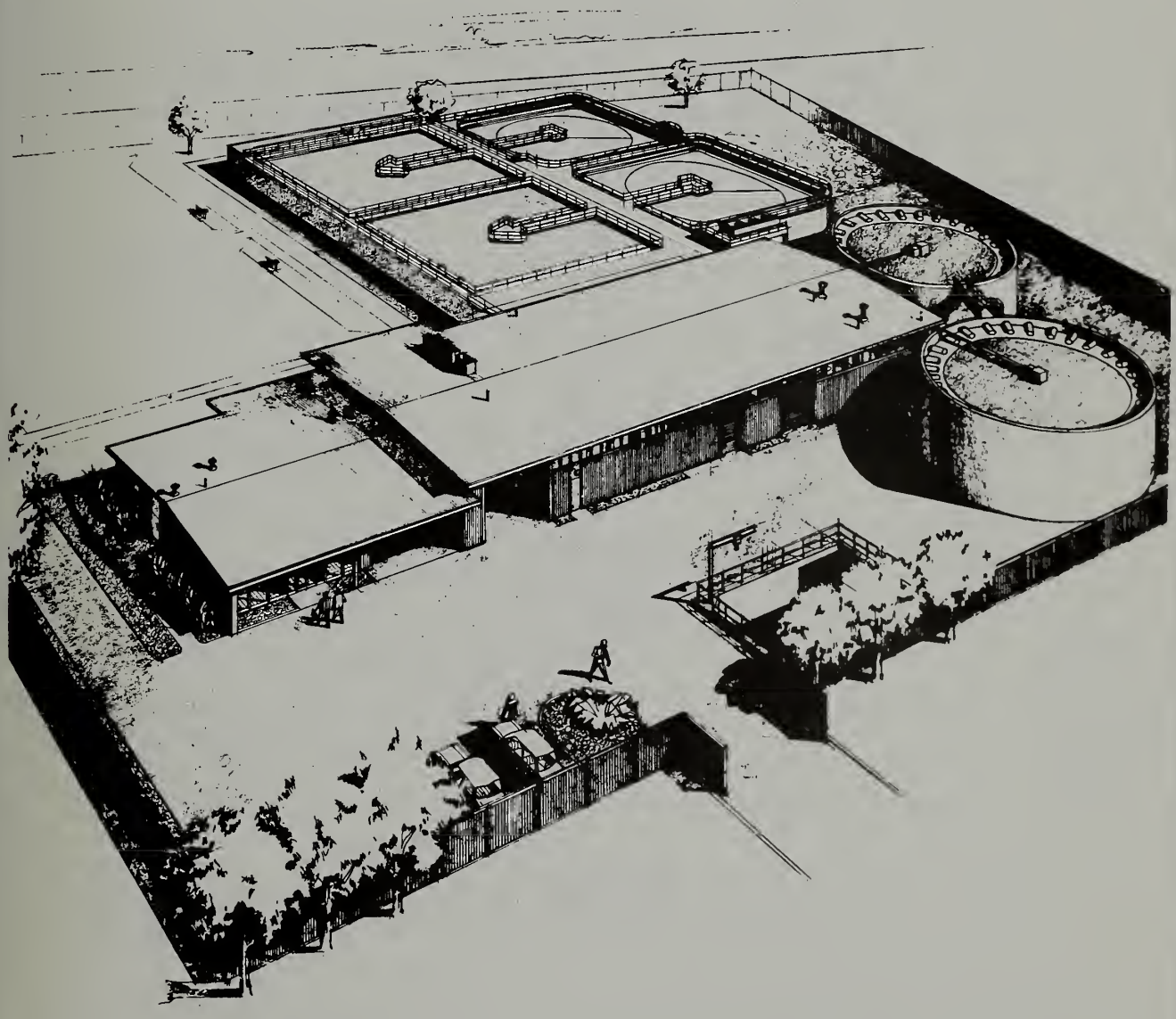
The northern portion of the system drains the remainder of the airport property. The drains discharge to the former Administration Building Canal, now called the Old Bayshore Canal.

EXHIBIT E-6
San Francisco International Airport
SANITARY SEWAGE TREATMENT
PLANT

CITY AND COUNTY OF SAN FRANCISCO
AIRPORTS COMMISSION

SAN FRANCISCO INTERNATIONAL AIRPORT

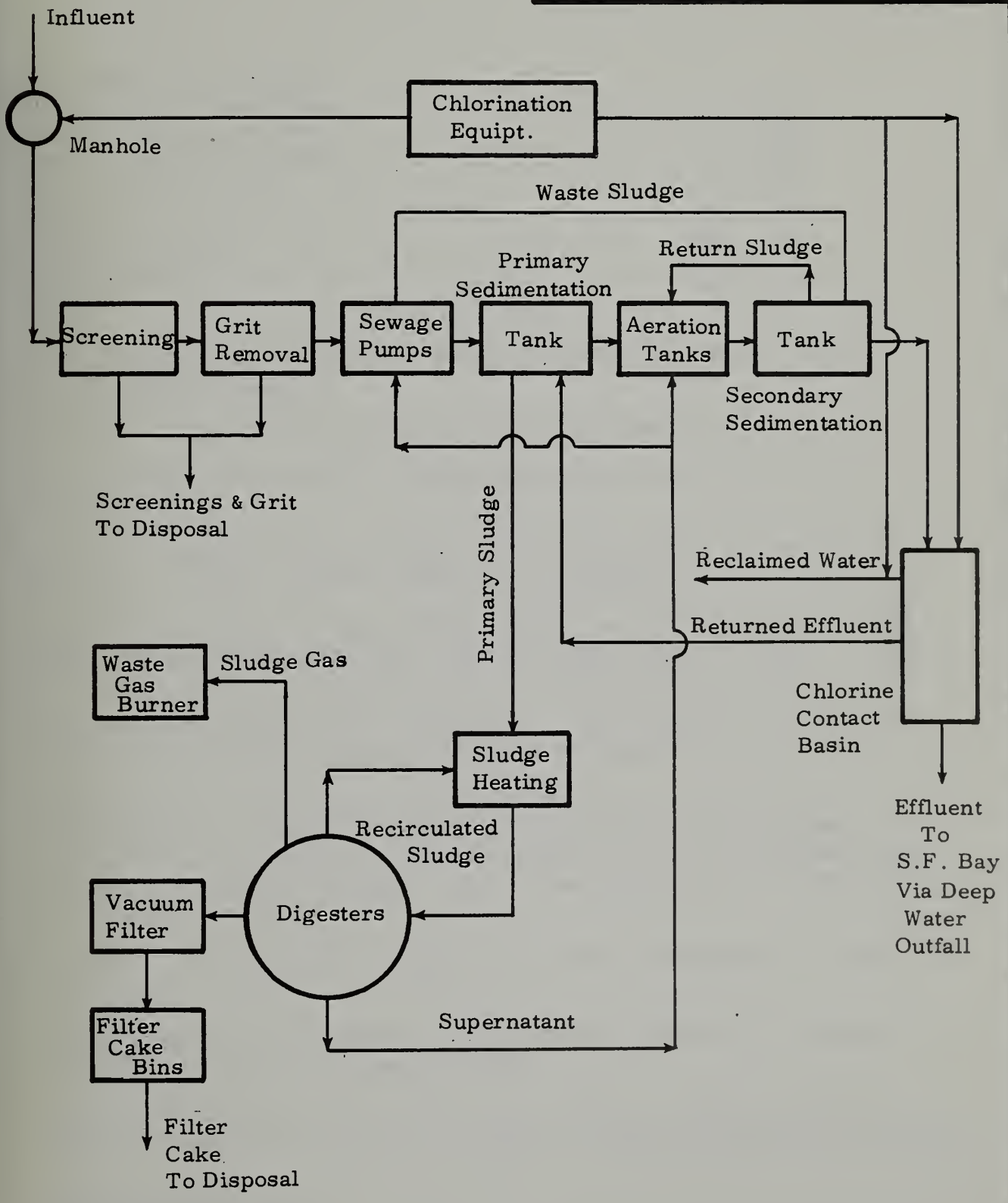
WATER QUALITY CONTROL PLANT



Source: SFIA Engineers

EXHIBIT E-7

San Francisco International Airport
TREATMENT FLOW DIAGRAM



Source: SFIA Engineers

EXHIBIT E-8

San Francisco International Airport

SANITARY TREATMENT PLANT DESIGN CRITERIA

INCOMING WASTE WATER:	
Design average daily flow	2.2 mgd
Design peak hourly flow	3.3 mgd
Design peak flow (hydraulic)	4.4 mgd
Present minimum flow	0.6 mgd
B.O.D.	250 ppm
Suspended solids	250 ppm
Volatile solids	85%
Grease	75 ppm

GRIT COLLECTOR: An endless chain mechanism with a screw conveyor for land disposal of grit.

SCREENS: One bar rack and 2 mechanical bar screens.

RAW WASTE WATER PUMPS: One constant speed drive and 2 variable speed drive.

PRIMARY SEDIMENTATION: Surface loading, 800 gallons per square foot per day. 2.5-hour detention, 20% B.O.D. reduction.

AERATION: 2 tanks, B.O.D. loading 33 lbs. per 100 lbs. B.O.D./day/lb. MLSS. Solids loading 2000 ppm. Return solids pumps, 2.2 mgd. Aeration units are operated as in the conventional activated sludge process.

SECONDARY SEDIMENTATION: One tank, surface loading 700 gallons per square foot per day, 2.5-hour detention at 2.2 mgd.

DISINFECTION: 25 minutes in chlorine contact basin and 9 minutes in outfall sewer. 3 chlorinators, 1 for pre-chlorination and 1 for post-chlorination each of 2000 lbs. per day capacity, and 1 for reclaimed water chlorination of 100 lbs. per day; flow proportional control for influent and effluent chlorinators.

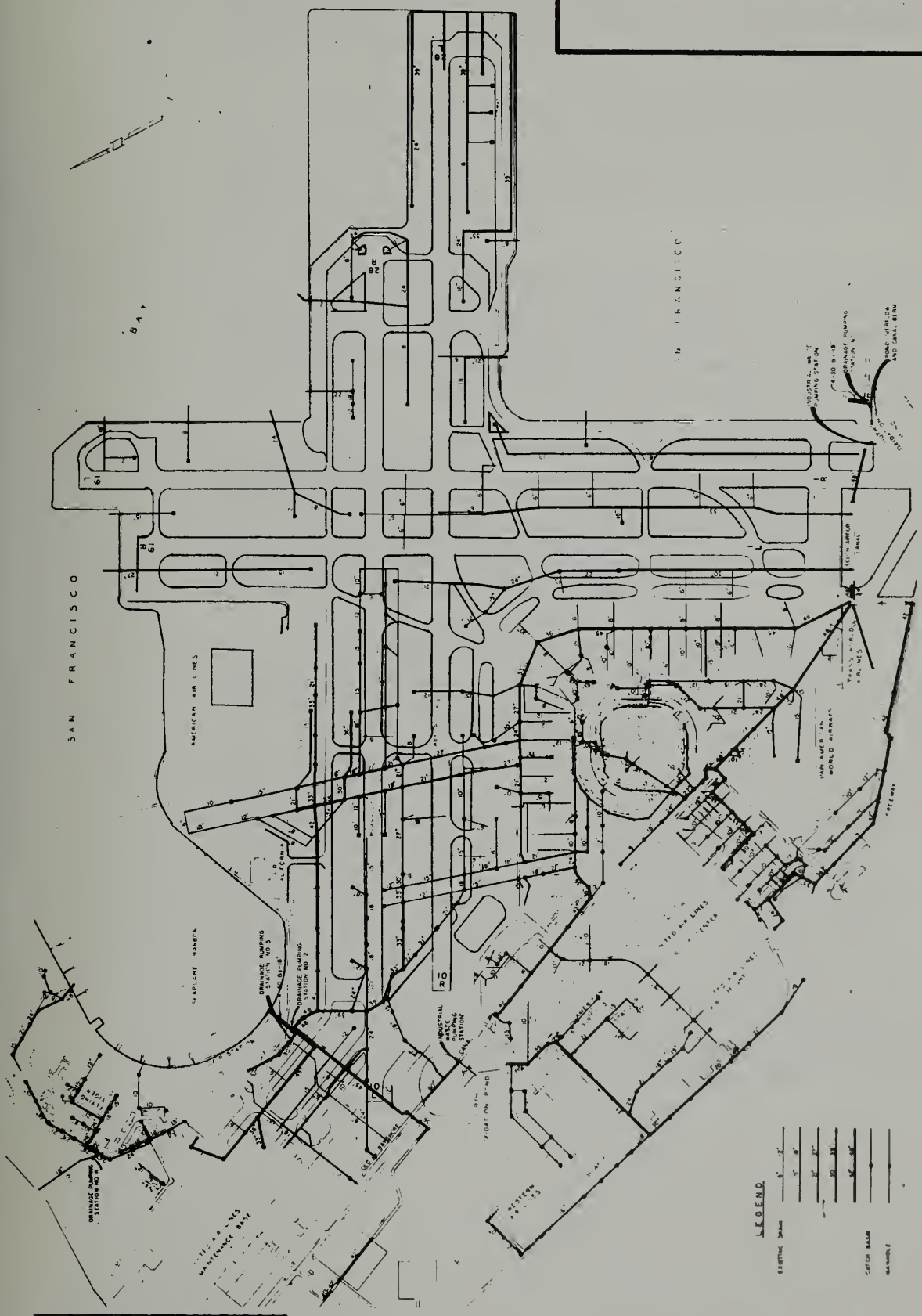
RECYCLE: A portion of the treated waste water is reclaimed for various plant uses.

SOLIDS HEATING AND DIGESTION: The solids are heated and digested in 2 tanks, 82,680 cu. ft. total capacity.

SOLIDS CONDITIONING: One rotary vacuum filter for dewatering sludge to minimum water content for hauling to disposal. Sludge beds available for standby.

Source: SFIA Engineers

EXHIBIT E-9
San Francisco International Airport
DRAINAGE UTILITIES PLAN



Source: SFIA

Dry weather flow is pumped from the canal into the North Oxidation Pond for treatment of industrial wastes. The excess flow in the canal during wet weather is collected by a 45-inch drain which carries the flow to Drainage Pumping Station No. 2 where it is pumped to the Bay at the Seaplane Harbor.

The peripheral drains have all been installed with tide gates. The gates have become corroded and encrusted with marine growths which prevent the complete closure at high tide. As a result, some water backs up into the drainage system at high tides.

The major drains parallel to runways 1L and 1R are believed to be restricted near their outlets into the South Airport Canal. These lines cross the Old Bayshore Highway embankment which undoubtedly has not been settling as fast as the runway area fill over most of the length of the drains.

Poor slopes also have resulted from differential settlement in other areas. Sections of primary drains which have settled considerably below the average invert grade may need to be inspected and cleaned periodically to assure the free flow of stormwater. Severe grade changes should be corrected by removing and replacing the drain.

The 45-inch drain from the Old Bayshore Canal to Pumping Station No. 2 now serves considerably more area for which it was originally designed. The area of about 100 acres west of the Old Bayshore Highway from the North Oxidation Pond to the North Canal originally drained to the North Canal. The outlet from this area into the North Canal was plugged to prevent backflow from the canal at high tide. The area now drains into the 45-inch drain to Pumping Station No. 2. This drain serves a total area of about 375 acres; it was originally designed for less than one-half that acreage. In addition, about half of the acreage has been paved since the installation of this main. The 45-inch main may not be capable of handling expected stormwater flows without flooding of the area adjacent to the Old Bayshore Canal north of runways 10L and 10R. Considerable flooding may also occur in the areas between South Airport Boulevard and the Bayshore Freeway.

3. Present Industrial Wastewater Treatment

The tenant-owner relationship at the airport provides that each tenant is responsible for collecting all industrial waste generated in his own area, with the exception of the passenger terminal area and some cargo areas. The tenant must construct all buildings and pipelines and may connect to the airport's drainage systems at only one point. The terminal buildings are constructed by the airport to the tenants' specification. The tenants are required to comply with airport regulations which provide for the location and nature of their operations and the quality and method of disposal of their wastes.

The industrial waste produced in shops and service hangars is handled in one of three ways: isolation, separation, or treatment.

The tenants maintain oil and waste collection tanks. Concentrated wastes such as used crankcase oil, paint thinners and cleaning solvents are isolated at the source and collected for ultimate disposal off the airport site by a scavenger. This method, if properly and diligently followed, eliminates the waste from the collection system.

On pipelines which lead away from known sources of industrial waste which cannot be isolated, such as outdoor steam cleaning points, hangar floor gutters and aircraft washing areas, the tenants maintain gravity oil and grease separators. There are many different sizes and types of separators being used and their ability to separate wastes varies considerably. They all have the basic problem of short detention periods and require frequent cleaning. The efficiency of many of the separators is hampered by the fact that the oil and grease is held in suspension by strong detergents. Waste from the separators is disposed in waste collection tanks, while the effluent drains into the storm drain system.

Some of the airlines and related industries have wastes which are of a nature that they may not be discharged without pretreatment. The treatment plants for these wastes are primarily designed for oil and grease removal except for the United Airlines Maintenance Base which is more extensive. All of the pretreatment plants are currently under study because of the need to comply with the airport's relatively new waste discharge regulations.

All the industrial wastewater, except that from several sources which are not connected to the airport storm sewer system, is pumped into the existing North or South Oxidation Ponds during dry weather. During wet weather, the flow in excess of pump capacity to the oxidation ponds is diverted and discharged directly to the Bay. The diverted flow is a mixture of storm water and industrial waste water.

The two existing oxidation ponds are designated as the South Pond and the North Pond. The South Pond has a capacity of approximately 2,300,000 gallons which provides about 15 days of detention time for dry weather flow from the south area. The capacity of the North Pond is approximately 15,600,000 gallons and provides 16 days detention for industrial waste from the north and northeast areas.

The industrial wastewater collected by the existing storm drainage system is transported to channels where pump stations are located. When the flow reaches a predetermined elevation, the pumps are activated and the wastewater is pumped into the ponds. While the wastewater is being held in the channels, the oil floats to the surface and the solids settle to the bottom of the channel. The oil and solids accumulate in the channel until it rains. Then the accumulated oil, along with a portion of the settled solids, is flushed to the Bay. Therefore, the ponds' influent and effluent waste characteristics are not representative of the actual waste loadings or removal efficiencies.

Oil and grease are further separated from the waste water in the pond. However, without any skimming mechanisms, the floating oil is swept by the wind across the pond, onto the banks and some drifts over the weir and to the effluent pump station. The oil is seldom pumped from the wet well until there is a storm. Most of the suspended solids in the wastewater settle in the pond. However, the algae growth in turn creates suspended solids which appear in the pond effluent and contribute to the effluent BOD. If the two oxidation ponds were to remain in service, provisions would have to be made for removal of oil and algae. However, even then, heavy metal removal would possibly remain a problem.

There does exist the potential for improper handling of industrial wastes. This includes failure by airport tenants to observe good housekeeping practices, accidental or deliberate dumping of oily or toxic wastes, and improper maintenance of oil and grease traps. The airport management has tried to ameliorate the situation in various ways:

- Educational programs with tenants
- Constant follow-up to observe and promote good management practices for their oil and grease facilities.
- Initiation of a vigorous monitoring program.

Exhibit E-10, on the following page, shows the citation forms issued to tenants found in violation of good waste management practices.

4. Proposed Industrial Wastewater Treatment Facilities

An industrial wastewater treatment system is an element of the expansion program at SFIA. In 1973 the Airport Commission retained Consoer, Townsend and Associates to prepare a plan for such a system. The study by Consoer, Townsend and Associates supplemented by an additional study provides the preliminary design for the treatment of industrial wastewaters (3), (4).

The proposed system incorporates a collection network as presented in Exhibit E-11, which follows Exhibit E-10. The industrial wastewater treatment facilities would include:

- An equalization pond of one million gallons capacity, incorporating some skimming device to remove oil.
- Oil separators for the removal of easily separated oil.
- Separators for the dispersed oil, including addition of acid, ferric chloride or alum.
- Chemical treatment for heavy metals removal.
- A biological final treatment, preferably a biofilter for removal of phenols and other organic substances.

Source: SFIA Engineers

AIRPORTS COMMISSION
VIOLATION ADMONISHMENT
SAN FRANCISCO INTERNATIONAL AIRPORT

Nº 15126

Date_____

Time_____ a.m. p.m.

VIOLATOR: Employee_____ (Name) (Badge #) Employer_____

If vehicle involved:

Vehicle #_____ Type_____ Driver's License #_____

VIOLATION: Location_____ Rules and Regulations Section #_____

Description_____

Issued by _____ (Name) (Title)

COPY FOR EMPLOYER (Please See Over)

TO THE EMPLOYER

This violation is brought to your attention so that you will institute further action deemed necessary and appropriate to comply with the Airport's Rules and Regulations. Please indicate action below and return this Admonishment to the Airport Operations Superintendent, Room G-18, South Terminal, San Francisco International Airport, San Francisco, California 94128.

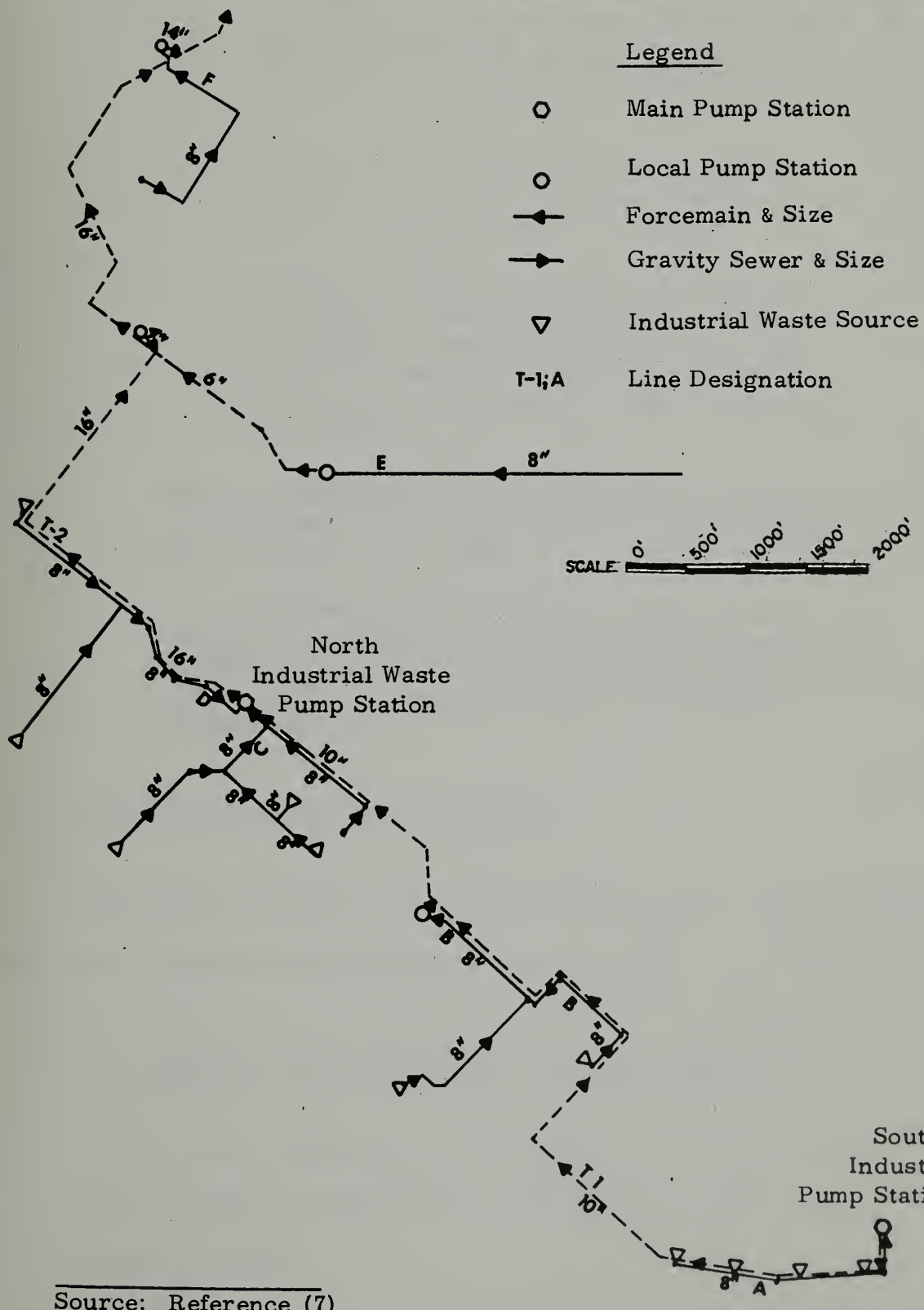
Employer's authorized Representative_____ (Signature) (Title)

EXHIBIT E-10
San Francisco International Airport
VIOLATION CITATION FORM

EXHIBIT E-11

San Francisco International Airport
INDUSTRIAL WASTE WATER TREATMENT
PROPOSED COLLECTION SYSTEM

September 1973



Source: Reference (7)

In addition, Consoer, Townsend recommend that the effluents from the present sanitary and proposed industrial wastewater treatment facilities be subjected to additional combined treatment. The elements of the joint treatment system would be:

- A biological oxidation treatment (nitrification) for the reduction of the ammonia nitrogen concentration of the effluents down to the expected discharge requirement of less than 6 mg/l.

- A final filtration step to reduce the suspended solids concentration to below the expected discharge requirement of less than 8 mg/l.

- A chlorination-dechlorination unit to disinfect the effluent. (This would completely overcome the problem of excessive fecal coliform counts, even in the case of accidental or deliberate diversion of aircraft sanitary waste to the industrial sewers).

After the joint treatment stage, the combined effluents would be discharged approximately one mile out into the Bay by way of the San Bruno outfall.

The schematic representation of the proposed system is presented in Exhibit E-12, on the following page. The net effect of this treatment would be to meet the discharge requirements presented in Exhibit E-13, following Exhibit E-12.

4. IMPACT OF FUTURE DEVELOPMENTS

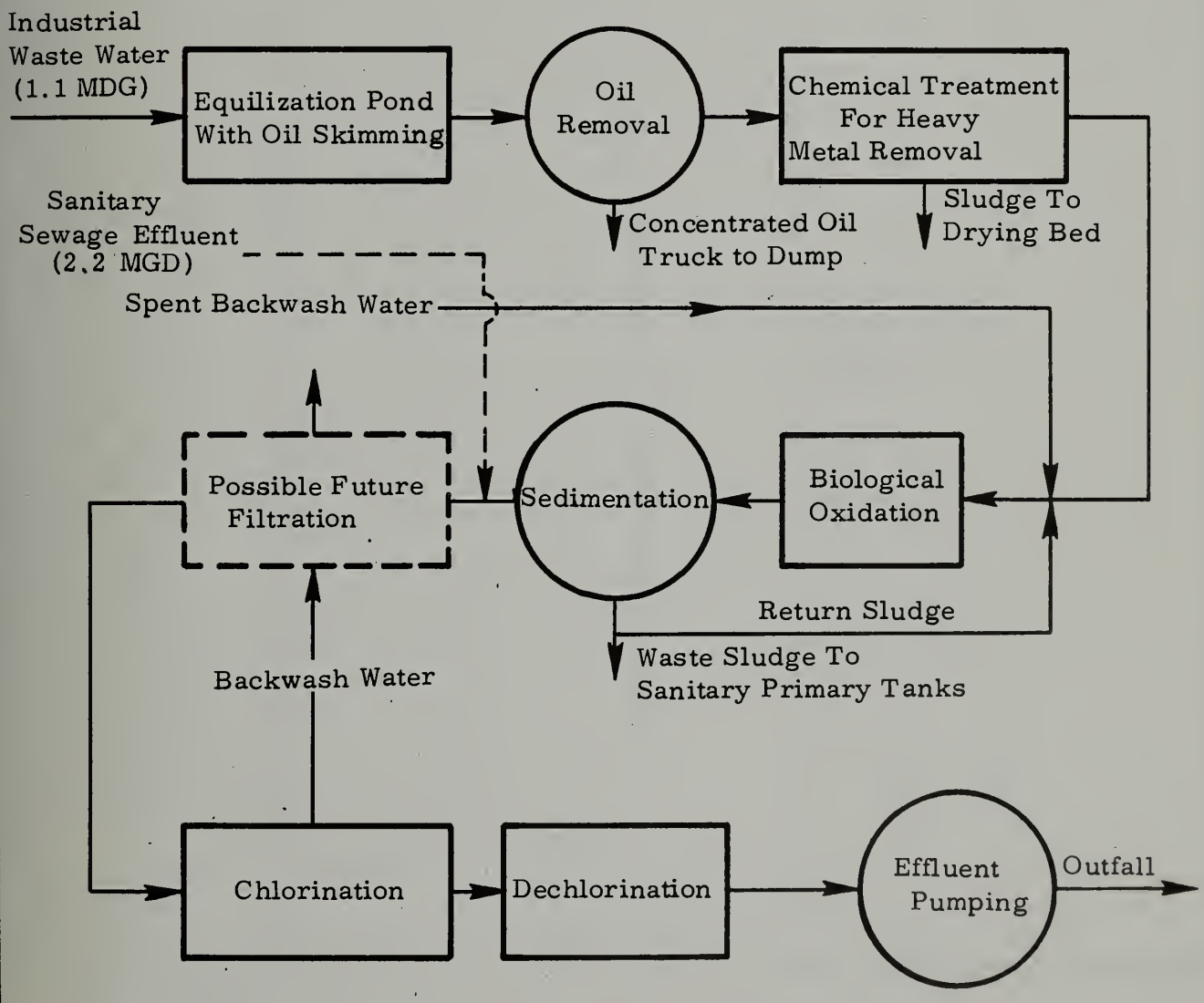
This section summarizes the probable impacts of future developments on the water resources and on the aquatic environment.

(1) Impact of Water Requirements on Water Resources

The water requirements of the airport will not significantly affect the rest of the community, nor overtax the present water distribution system.

EXHIBIT E-12
San Francisco International Airport

GENERAL INDUSTRIAL WASTE
TREATMENT FLOW DIAGRAM



Source: Reference (4)

EXHIBIT E-13

San Francisco International Airport

EFFLUENT DISCHARGE REQUIREMENTS

Constituents	30 Day Average	Maximum Daily	Instantaneous Maximum	50% of Time	10% of Time	Possible Future Requirement
Settleable Solid (ml/l hr)	0.1	-	0.2	-	-	
BOD (mg/l)	30	20	-	-	-	10
Suspended Solids (mg/l)	8	16	-	-	-	8
Oil & Grease (mg/l)	30	20	-	-	-	-
Chlorine Residual (mg/l)	-	-	0	-	-	-
Total Ammonia (mg/l)	-	-	-	-	-	6.0
Turbidity (jtu)	10	20	-	-	-	-
Arsenic (mg/l)	-	-	-	0.01	0.02	-
Cadmium (mg/l)	-	-	-	0.02	0.03	-
Total Chromium (mg/l)	-	-	-	0.005	0.01	-
Copper (mg/l)	-	-	-	0.2	0.3	-
Lead (mg/l)	-	-	-	0.1	0.2	-
Mercury (mg/l)	-	-	-	0.001	0.002	-
Nickel (mg/l)	-	-	-	0.1	0.2	-
Silver (mg/l)	-	-	-	0.02	0.04	-
Zinc (mg/l)	-	-	-	0.3	0.5	-
Cyanide (mg/l)	-	-	-	0.1	0.2	-
Phenolic Compounds (mg/l)	-	-	-	0.5	1.0	-
Total Identifiable Chlorinated Hydrocarbon (mg/l)	-	-	-	0.002	0.004	-
pH	-	6 to 9	-	-	-	-
Fecal Colform (1) (per 100/ml)	200	-	-	-	-	-
Toxicity (2) %	-	50	-	-	-	-

(1) Geometric Mean

(2) 96 hour bioassay: Survival in 100% wastewater

Source: Reference (4)

1. Impact of Water Requirements on Water Supply

As noted previously, the projections of the general water usage in metropolitan San Francisco, indicate that the airport requirements represent about one percent of the total system demand. This percentage requirement will not significantly change as a result of proposed development at SFIA.

2. Impact of Water Requirements on Distribution System

The distribution system presently installed has been estimated by Metcalf and Eddy (1) to be adequate even for peaks of 7.5 mgd. Of particular interest is the conclusion that even under peak condition the system would not be overtaxed by a demand of 7,000 gpm for a fire fighting operation.

(2) Impact of Increased Wastewater Volumes

The anticipated increase in volume of sanitary waste can be handled by present sanitary facilities. With proper supervision and cooperation of the tenants, the anticipated increases in industrial wastewaters would not result in significant deterioration over the present conditions. The implementation of the industrial wastewater treatment scheme would result in a considerable improvement over present conditions.

1. Sanitary Wastes

The most conservative estimate of wastewater loads corresponding to 31 MAP in the year 1990 is for an average of 1.6 mgd with an expected one day maximum peak of 3.0 mgd. As can be seen from Exhibit E-8, the present sanitary waste treatment facilities are adequate to handle this forecast load.

2. Industrial Wastes Without Modification to the Present System

As shown in the preceding sections, the increased activity at the airport would result in a very modest increase in industrial wastes (5 to 10 percent) over the present situation. Better understanding on the part of the tenants and better policing on the part of the airport management would result in some improvement over the present situation.

3. Industrial Wastes After Installation of Proposed Facilities

The beneficial impact of the proposed new industrial waste facilities is significant. The heavy metals discharge would be greatly reduced, the oil and grease would be controlled and the adverse effect of improper disposal of aircraft waste would be eliminated.

(3) Impact of Additional Construction on Storm Runoff

Most of the proposed structures are on land already paved, thus no significant effect on storm runoff is anticipated.

The proposed segregation of industrial wastes would also result in an improvement of the quality of the early portions of runoffs, since the chances of washing out accumulations of concentrated wastes in common sewers would be reduced.

Finally, improvements in the handling of aircraft sanitary wastes would also minimize the possibility of coliform contamination of storm sewerage.

(4) Summary and Conclusions

The significant effects of the anticipated developments at SFIA in regard to water usage and wastewater generation and control can be summarized as follows:

- Water usage at the airport, currently about 1.8 mgd, is expected to increase to about 2.6 mgd in 1982 and 3.4 mgd in 1990. Peak usage may be as high as 4 mgd in 1982 and 5.2 mgd in 1990. The supply and distribution systems are adequate to 7.5 mgd of peak use.

- Sanitary waste loads which are currently about 0.9 mgd are expected to be 1.1 mgd in 1982 and 1.6 mgd in 1990. The sanitary wastewater plant is designed to treat 2.2 mgd average daily flow and can absorb upsets of 3.3 mgd peak hourly flow and 4.4 mgd hydraulic peak flow.

- Industrial wastes are at present on the order of 1.3 mgd average. These wastes are expected to be about 1.4 mgd in 1982 and 1990.[1/] .

- A complete industrial wastewater treatment system is part of the overall expansion program. This system will meet the most stringent requirements of waste discharge to the San Francisco Bay waters. In addition, the outfall of the treated industrial wastes will be moved one mile offshore (as is the case at present for the treated sanitary wastes).

- Additional facilities will not signficantly increase the paved area over present conditions and thus should have no signficant effect on storm runoffs.

1/ It may be noted that whereas in 1974, water usage is less than the total wastewater flows due primarily to infiltration, in 1982 and 1990, usage exceeds wastewater flows. This apparent dichotomy arises from the fact that passenger utilization, the quantities of water usage and sanitary wastes increases drastically during this period, while aircraft operations, the quantities of industrial waste flows remains fairly constant.

In conclusion it can be stated that the anticipated developments at SFIA:

- Will not overtax the present water supply system
- Will not overtax present sanitary treatment facilities
- Will result in improved industrial wastewater treatment
- Will result in a lessening of the potential deleterious impact of airport operations, on the aqueous environment

References

1. Metcalf & Eddy, Inc., Report to the City and County of San Francisco Airport Commission on Addition and Improvements to the Water, Sewage, Drainage and Gas Systems for San Francisco International Airport, 1970

2. Metcalf & Eddy, Inc., Private Communication, January 1975

3. Consoer, Townsend & Associates, Preliminary Design Study - Industrial Waste Treatment and Collection Facility, 1973

4. Consoer, Townsend & Associates, Supplemental Preliminary Design Study - Industrial Waste Treatment and Collection Facilities, 1974

APPENDIX F

GEOLOGICAL ASPECTS OF THE SAN FRANCISCO INTERNATIONAL AIRPORT EXPANSION PROGRAM

APPENDIX F

GEOLOGICAL ASPECTS OF THE SAN FRANCISCO INTERNATIONAL AIRPORT EXPANSION PROGRAM

The proposed expansion of SFIA's terminal complex will have no impact on the geology of the Bay Area. However, the expansion program does involve a significant investment of community resources and it is appropriate, therefore, in an earthquake prone area, to explore the possible effects on the community's investment in time of a national disaster.

Airports in general are relied upon to remain functional after a disaster to provide a base for logistics and communications for the support of relief operations. Experience has shown that airport personnel have managed to provide these services under quite adverse conditions. For obvious reasons, an airport's role is one of responding to geological phenomena rather than inducing them. Since an airport's ability to respond can play a major role in the community's ability to recover quickly from natural disasters, the survivability of SFIA in time of such a disaster is a subject of significant interest and is appropriate in this EIAR.

1. INTRODUCTION

This appendix provides the background and supporting information for assessing the potential effects of earthquakes and tsunamis on SFIA. Information on the geological history, soil properties, and settlement

history have been reviewed and summarized. The seismic effects on Bay Area soils and fill materials have been described and the potential effects of tsunamis are discussed. A review of the effects of earthquakes on other airports has been undertaken and forms the basis for the assessment of the environmental impact of geological phenomena on SFIA.

2. GEOLOGY OF BAY AREA

The San Francisco area is one of the most active geological areas in the United States. The bay trough was developed less than 1.5 million years ago and was flooded by the general rise in sea level during Wisconsin time due to glacial melting.

(1) Geology of Airport Area

The general area of San Francisco International Airport, including the proposed expansion site, is situated on depressed segmented rock wedged between two uplifted fault blocks which are associated with the complex San Andreas Fault System. The geological history was described by Goldman, in Geological and Engineering Aspects of San Francisco Bay Fill, (p. 14), California Division of Mines and Geology, Special Report 97, 1969 (1).

The San Francisco Bay Area as it is known today came into existence in mid- to late-Pleistocene time. Rocks of the Franciscan Formation were deposited in extremely deep, narrow troughs at the

foot of the continental slope from late Jurassic to mid-Cretaceous time. Sediments of the Knoxville and Cretaceous formations were deposited on shallower marine shelves, as were also sedimentary and volcanic materials of the Tertiary period. After deposition of extensive Cretaceous and Tertiary sediments, the formations were folded (bent) and faulted (broken) by a series of earth movements into the northwest-trending structural pattern of the central Coast Ranges. During latest Miocene and much of Pliocene time, the bay block was high-standing and was being eroded to supply sediments both to its west and east.

The San Francisco Bay trough did not come into existence until the end of the Pliocene epoch or during the Pleistocene. It was formed by a combination of warping and faulting. The San Francisco-Marin block was tilted toward the east, with the western edge forming the San Francisco and Marin hills, and the depressed eastern edge forming the uneven depression in which the bay now lies. In Pleistocene time (within the last one million years) the trough was nearly filled with sediments, some of marine origin, other derived from the surrounding hills.

During the interglacial stages of the Pleistocene epoch, the trough which became San Francisco Bay was flooded by the general rise in sea level due to the release of melt water from glaciers in other parts of the world. Bay mud was deposited during and after

the melting of the continental glaciers in Wisconsin time, (i.e., the fourth stage of the glacial epoch of North America from about 125,000 B.C. to the post glacial age.

* * * * *

This history of extensive earth movements accounts for the development of the seismically active fault systems which lie along the perimeter of the bay. The changes in sea level occurring during more recent glaciation history have deposited soft, relatively unconsolidated bay mud to varying depths over the pre-existing bedrock. The continuation of active faults and poor solids results in the relatively high probability for strong earthquakes and extensive damage in the Bay Area.

(2) Active Fault Systems

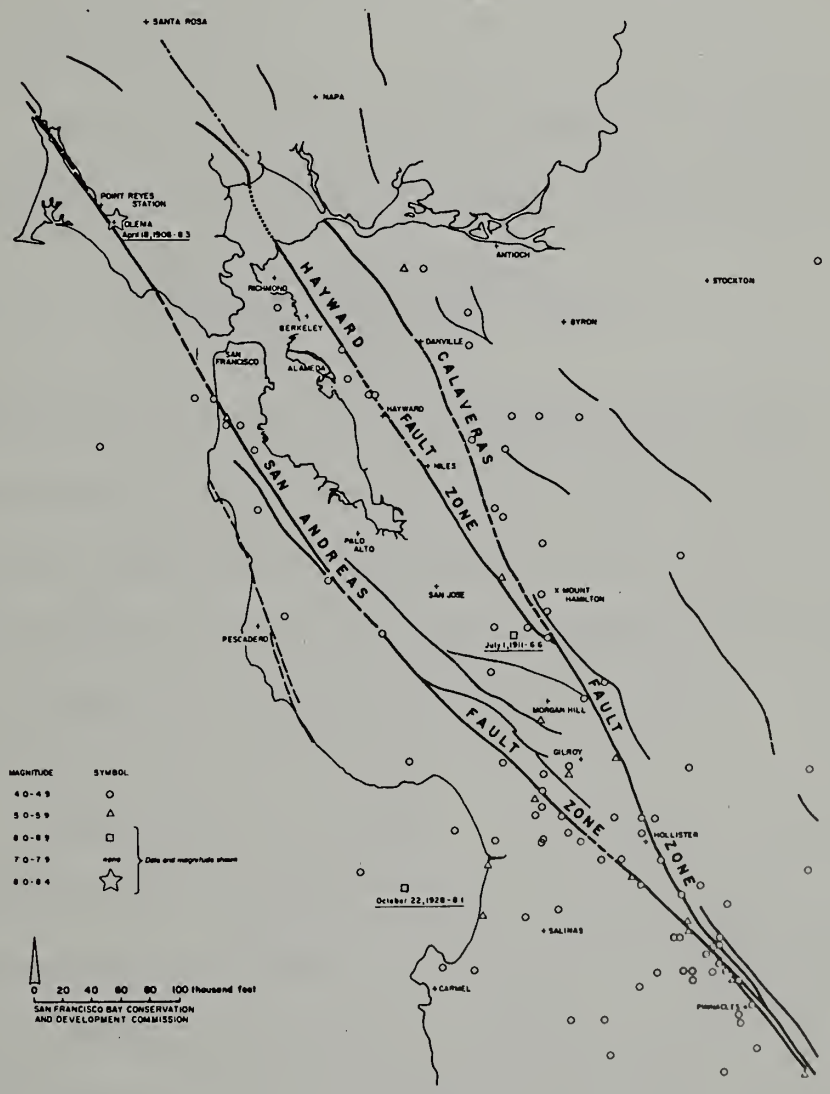
The San Andreas Fault lies about three and one-half miles west of SFIA. It transects the San Francisco Peninsula on a north-northwester direction and lies approximately three miles southwest of SFIA. The other major faults in the area are the Hayward and Calaveras faults lying approximately parallel to the San Andreas Fault on the eastern side of the bay. Geologically, the major faults, and some of their branches are active and account for the high frequency of earthquakes in the Bay Area. Exhibit F-1, on the following page, illustrates the

EXHIBIT F-1

San Francisco International Airport

LOCATION AND MAGNITUDES OF EARTHQUAKES IN THE BAY AREA

(1934-1965) (2)



Source Reference (2)

the Bay Area fault system and shows the earthquakes of intensity greater than 4 for the period 1934 to 1965. (There have been more than a dozen damaging earthquakes in the bay counties during the last century, and it appears reasonable to expect a great earthquake (comparable to San Francisco, 1906) to occur once in sixty to one hundred years.)

(3) Soil Properties

The soils underlying and surrounding San Francisco Bay are sedimentary layers of three basic types of soil material over bedrock.

- Upper (younger) Bay Mud
- Dense Silty Sand (sandy deposits)
- Lower (older) Bay Mud

In some areas there are lenticular formations of firm dense sand between the Lower Bay Mud and bedrock. The engineering properties of the mud sediments are shown in Exhibit F-2, on the following page. The properties of the Upper Bay Mud and Dense Silty Sand preclude the embedding of foundation piles in these materials.

Test borings at the airport indicate at least five layers of soil materials in the area of the proposed expansion. In the soil survey conducted by Lee & Prazker (4) in conjunction with the Bond Issue of 1967, the following general soil characteristics relating to the foundations of the terminal buildings, rotundas and aprons were found:

EXHIBIT F-2

San Francisco International Airport

ENGINEERING PROPERTIES OF BAY MUDS (3)

Properties	Older bay mud	Younger bay mud	
		Semi-consolidated member	Soft member
Degree of preconsolidation	Greater than weight of overlying sediments and greater than that of semi-consolidated member	Greater than weight of overlying sediments and greater than that of soft member. Preconsolidation is about one-half that of the underlying older bay mud	Normal consolidation
Increase in density on drying	High dry density (stiff to very stiff clay). Density is greater than semi-consolidated member	Marked decrease in dry density (as compared to the older bay mud) at the rate of 10 to 25 lbs. per cu. ft.	Less than 10 lbs. per cu. ft.
Average water saturated weight	131 lbs. per cu. ft.	110 lbs. per cu. ft.	97 lbs. per cu. ft.
Average weight submerged in water	68 lbs. per cu. ft.	47 lbs. per cu. ft.	34 lbs. per cu. ft.
Average moisture content	Less than 40 percent	About 40 percent	Greater than 40 percent
Compressive strength	1,000 to 4,000 lbs. per sq. ft.	1,000 lbs. per sq. ft.	200 lbs. per sq. ft. Strength is a function of pure cohesion and no coefficient of friction exists
Foundation characteristics	GOOD Foundation for piles and other similar structures, and for all but heavy, concentrated load	FAIR Foundation for earthfill having a broad base. Not good for piles or other similar structures	POOR Piles, and other similar structures tend to sink of their own weight
Special properties			Sensitive clay. Swells when wet, tends to desiccate when dried in air[1]
			Highly compressible
			Loses 50 percent of strength when disturbed. Regains strength due to thixotropic action[2]
Origin	Results from flocculation of clay colloids in salt water. Tends to deflocculate when placed in fresh water		
Thickness	Up to 200 feet	Up to 60 ft., 40 ft. average	Up to 70 ft., 60 ft. average
Physical properties and mineralogy	Firm clay with varying amounts of silt and lenses of sandy clay, sand and small-sized gravel. Minus 2-micron sizes are 50 percent normal and hydrated mica; plus montmorillonite, chlorite, diatoms, carbonaceous material, quartz, feldspar. (Schlocker and others 1958)	Plastic, silty clay, and clayey silt, with varying amounts of organic matter, clayey fine-grained sand, and some shell lenses. Clay sizes are 45 to 90 percent of total; ⅓ normal and hydrated mica; ⅓ montmorillonite, and ⅓ mixed-layered montmorillonitic, chloritic, and kaolinitic material. Less than 5 percent carbonaceous material. (Schlocker and others, 1958)	

Notes

[1] The sensitive clay is already in a saturated state, and only when the clay is previously dried and water added will it swell.
[2] Some parts of the bay mud may lose as much as 90 per cent of its strength when disturbed.

Source Reference (3)

- All the proposed structures are underlain by manmade fill varying in thickness from 6 to 21 ft.

- All the proposed structures are underlain by Upper Bay Mud, which underlies the fill and varies in thickness from 19 to 60 ft.

- All the proposed structures are underlain by a fairly dense silty sand layer varying in thickness from 5 to 31 ft., which is sandwiched between the Upper Bay Mud and the Lower Bay Mud described below.

- All the structures are underlain by Lower Bay Mud of varying thickness from 7 ft. to 68 ft., extending to depths 130 ft. below existing ground surface.

- There generally is a layer of firm dense sand sandwiched between the Lower Bay Mud and the underlying bedrock. However, at the upper fringes of bedrock ravines this sand layer is absent and the Lower Bay Mud is in direct contact with the bedrock.

- The depth to bedrock within all the proposed structures varies from 62 to 152 ft. below existing ground surface.

Similar soil sedimentations were found in areas of the proposed garage and underpasses at the eastern and western ends of the main access road.

(4) Settlement History

The area now occupied by SFIA was reclaimed from the marsh and tideland commencing in 1880 when the portion west of the Old Bayshore Freeway was reclaimed by construction of earthern levees and drained. The area required draining for about forty years, and the continuous pumping of water induced a settlement of about 3 feet which lowered the ground surface to 3.5 ft. S.F.A.D. (San Francisco Airport Data

is 0.82 ft. above mean lower low water at Point San Bruno). The area east of Old Bayshore Freeway and north of the Central Terminal was reclaimed from marshland beginning in 1927. Filling operations were undertaken as needed until 1954 when the Central Terminal was constructed. In 1962, the South Terminal and Underground Garage were constructed on previously filled land. Between 1954 and the present, the major filling operations were:

- Fill of area of Plot 4 in 1954 for hangar and auxiliary facilities
- Fill of 50 of 180 acres west of Bayshore in 1970 for future development.
- Fill of approximately 55 acres along the north and east boundaries of the airport. This has been an ongoing process since 1968 under BCDC and U.S. Army Corps of Engineers permits.

The entire area of the airport, including runways and taxiways, because of the compressibility of fill and bay mud materials, has undergone progressive settlement. The variation in thickness of the fill materials, the bay mud, and the topography of the underlying geological structure has given rise to a wide variation in settlements and rates of settlement. Another factor contributing to differential settlement is that the area enclosed by the levee, built in 1880, was dessicated by farming activities and had undergone settlement prior to filling. The area outside and east of the levee was developed by filling directly on fresh bay mud. Exhibit F-3, on the following page, shows the airport superimposed on 1930 topography, which indicates

EXHIBIT F-3

San Francisco International Airport

AIRPORT SUPERIMPOSED
ON 1930 TOPOGRAPHY (6)

Source Reference (5)

that the original levee traversed the site just west of the Central Terminal, and would bisect the proposed North Terminal. The ground east of the Terminal should, therefore, settle at a faster rate than that west thereof. Measurements by the Airport Engineers showed that settlement over 20 years of the area west of the levee ranged between 0.9 ft. and 1.84 ft.; areas east of the 1880 levee have settled between 0.15 and 2.0 ft. during the same period.

Consultants to SFIA in 1967 extrapolated the historical settlement data and predicted settlements of the existing ground in the range of 1.2 ft. and 0.9 ft. for areas east and west of the Terminal area, respectively, given no changes in surface loading (6).

3. SEISMIC EFFECTS

The major geologic effect of concern at San Francisco International Airport is earthquake damage. To appreciate the potential effect, an understanding of the behavior of Bay Area soil and fill materials is required. Given this understanding, the potential effects can be estimated.

(1) Earthquake Effect on Soils

Moderate to strong earthquakes may produce a variety of effects, including surface faulting, vertical displacement, ground shaking, lurch cracking of alluvial or fill materials, compaction or liquefaction of soils and landslides, as well as tsunamis or seiches.

The specific local effects from an earthquake depend as much, if not more, on the condition of the soil than on distance from the epicenter or magnitude of the quake. In general, earthquake waves in passing from more dense solid rock to less dense alluvial and water saturated material tend to increase in amplitude and acceleration.

Ground shaking, due to earthquakes, produces different effects on different soil types. Generally, in cohesionless soils, compaction of soils with low clay content result in ground settlement; in saturated soils, high water pressures reduced by ground vibration causes an upward flow of water which liquifies these soils; this liquefaction phenomenon is rather common in earthquakes of moderate to large magnitude.

In the area of the SFIA, the fill materials will act somewhat differently than underlying bay mud and sand deposits to earthquake induced ground motions. The possible behavior of these materials under seismic loadings have been summarized in Exhibit F-4, on the following page.

(2) Earthquake Experiences at Airports

The following paragraphs were taken directly from A Study of Earthquake Losses in the San Francisco Bay Area, National Oceanic

EXHIBIT F-4
San Francisco International Airport
BEHAVIOR OF SOIL AND FILL MATERIALS UNDER SEISMIC LOADINGS

Foundation Materials

San Francisco Bay Mud

San Francisco Bay mud is a soft, slightly organic silty clay containing occasional thin seams or lenses of silt and sand. Its high water content and low preconsolidation pressure cause it to undergo substantial long term settlement under sustained loads and its low shear strength may lead to plastic flow in zones of substantial shear stress, such as occur at the edges of steep fill slopes under seismic loading.

a. Under level ground conditions, there is no evidence to indicate that the clay portion of the deposit would settle or liquefy during an earthquake.

b. The sand seams in the clay may liquefy during strong ground motions, but this is unlikely to have any serious effects unless the liquefied layer underlies or is immediately adjacent to a sloping surface and is located at a depth permitting sliding to occur. Otherwise the only effect would be a very small settlement as the pore pressures in the liquefied seams dissipated after the earthquake.

c. Slopes and adjacent land composed of or underlain by the clay may slide during an earthquake due to the additional forces developed in them by the earthquake, unless they are of sufficiently conservative design.

d. The deformable nature of San Francisco Bay mud will cause any deposit containing a substantial thickness of the clay to vibrate with a relatively low frequency of vibration. As a result, ground surface motions would have lower frequencies than those on adjacent areas not underlain by bay mud deposits. The influence of this effect will be discussed in a later section of this report.

Sand Deposits

Sand deposits in the bay are likely to be loose to medium dense and thus under earthquake loading conditions they are potentially vulnerable to:

a. Settlement due to soil compaction.

b. Liquefaction with resulting settlements of overlying materials and structures such as occurred at Niigata, Japan (1964).

c. Liquefaction and resulting flow slides such as occurred at Valdez and Seward during the Alaska earthquake of 1964.

The extent to which these effects might develop will depend on the in-place density of the deposit, the geometry of each particular case, and the intensity and duration of the earthquake. However, the possibility of these effects should be considered in cases where fills might be placed on sand deposits.

Fill Materials

Uncompacted Dumped Fill of All Types of Soil

Uncompacted dumped fills are naturally loose and form poor foundations for almost all types of structures. With time, however, they may densify sufficiently to support houses or other lightweight buildings. Under the influence of earthquake-induced vibrations, these materials:

a. Are likely to settle substantially, leading to appreciable differential settlements of buildings supported on them.

b. May liquefy if the fill is saturated and sandy in nature.

c. May undergo some degree of lateral movement due to differential movements within the fill.

d. May develop slides or slumping in sloping boundaries, especially where the fill is saturated.

The above effects are likely to be far more delcterious in their effects on structures than are any undesirable modifications of the ground motions, due to the nature of the fill itself.

Hydraulic Sand Fills

Hydraulic sand fills have been used extensively in the Bay Area. If the hydraulically deposited soil is not subsequently compacted, it is often in a loose to medium dense condition and thus during earthquakes is potentially subject to:

a. Some degree of settlement induced by the ground vibrations; however the settlement will be appreciably less than that of loosely dumped fills.

b. Possible liquefaction depending on the density achieved during placement, the depth of the water table and the intensity of the ground motions.

c. Flow slides if the sand should liquefy adjacent to unsupported sloping boundaries at the edges of the fill.

Source Reference (7)

and Atmospheric Administration (p. 167), U.S. Department of Commerce, NOAA, 1972(7). They summarize recent experience at airports in the U.S. in response to earthquakes.

The 1957 San Francisco earthquake had a magnitude of 5.3 and caused only minor nuisance damage at the San Francisco airport; the airport is located on structurally poor ground about 10 miles southeast of the epicentral region of the 1957 shock. Slowly occurring differential settlements around buildings were accentuated by the earthquake, and a number of underground pipelines broke as a result. Some minor structural damage occurred to several buildings, but no runway damage is known to have occurred.

The great Alaskan earthquake of 1964, with its 8.4 magnitude, provides a reasonable guideline for experience data from a great shock. A total of 13 airports were found to have had runway or taxiway damage out of 64 airports which were inspected. Virtually all airports were operational within hours after the shock despite runway damage and building damage. Some resourcefulness was required in order to accomplish this; for example, the collapse of the control tower at the Anchorage International Airport required the use of radios in a grounded plant for air traffic control.

Runways remained functional at airports in the San Fernando Valley after the 1971 San Fernando shock.

The foregoing incomplete experience record is rather reassuring with respect to the most important function of an airport, namely, to allow airplanes to land and to take off with people and goods.

* * * * *

In addition, during the 1964 earthquake at Niigata, Japan, magnitude 7.5, the airport building settled three feet and extensive liquefaction caused severe damage to runways and other facilities.

4. TSUNAMI AND SEICH EFFECTS

Tsunamis, or seismic sea waves, are ocean waves probably caused by faulting or other abrupt ground movements on the ocean floor. Seiches are oscillatory motions of enclosed bodies of water usually due to earthquakes with a moderate to large shock.

The Bay Area has been visited by tsunamis on infrequent occasions. Between 1868 and 1968 at least 19 tsunamis were recorded at the Golden Gate tide gate(9). The maximum recorded tide height was 7.4 feet. Specific damage inflicting tsunamis occurred in the Bay Area in 1960 and 1964 which were attributed to the Chilian and Alaskan earthquakes, respectively.

Primarily on the basis of the 1964 tsunami which resulted in loss of life and property at Crescent City, California, the Department of Interior, U.S. Geological Survey prepared a map showing the expected areas of

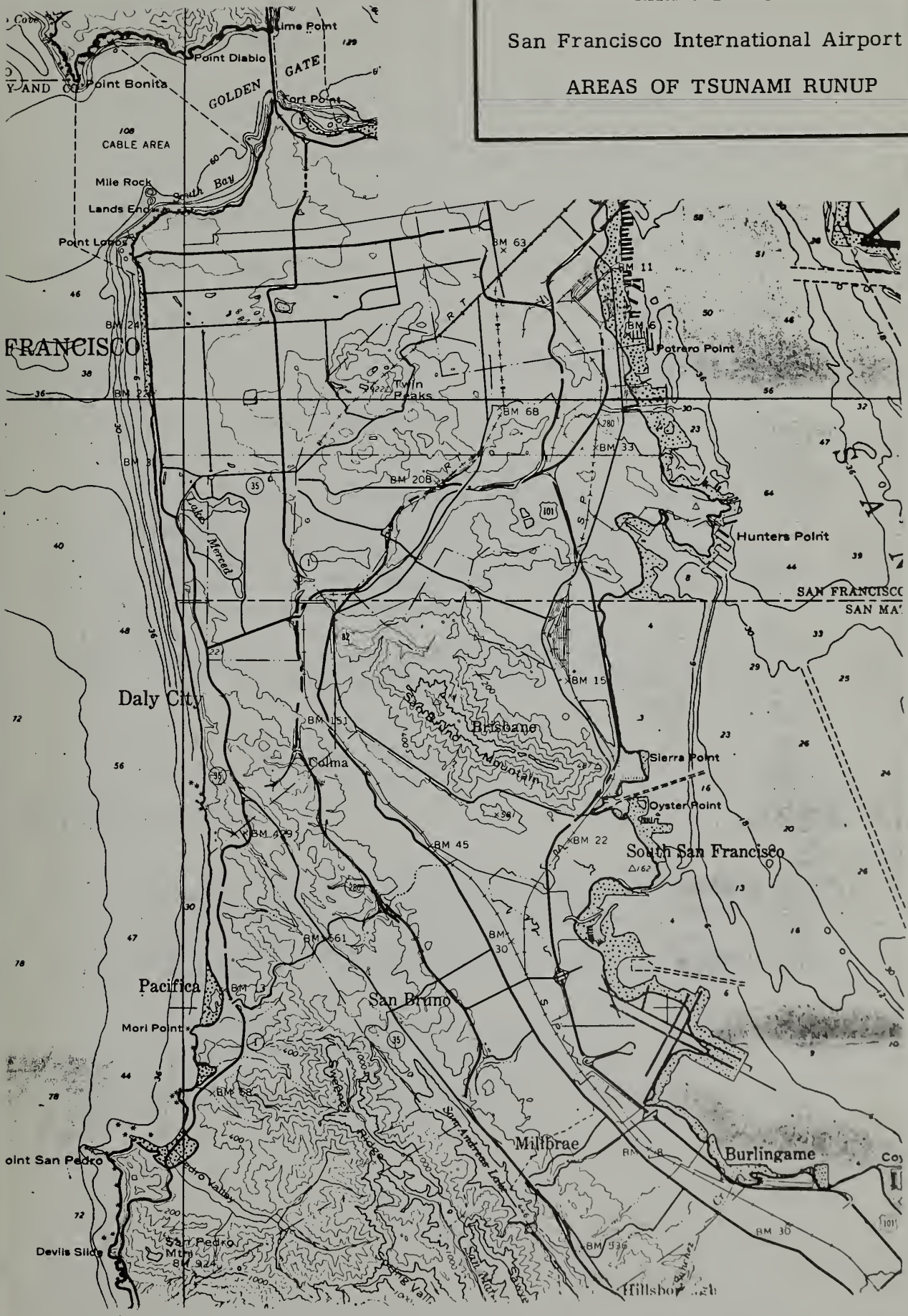
inundation by a tsunami having a 20 foot runup at the Golden Gate (10). The expected occurrence of such a wave is once every 20 years. In preparing the map, it was further assumed that the arrival time occurred at the time of tide of higher high water, a tidal state equaled or exceeded about four percent of the time. The portion of this map showing SFIA is given as Exhibit F-5, on the following page. The dotted areas indicate areas of inundation. It is to be noted that runways 19L, 19R, 28L, and 28R, as well as the Seaplane Harbor, would be partially inundated by a tsunami of this assumed magnitude. Public areas are not in the area of tsunami runup. It should also be noted that depth of water in the runup area should not be assumed to be twenty feet, and would probably be significantly less in the area of the airport since the wave at the tide gate would be dissipated by travel within the bay and over any land. In summary, tsunamis have low probability of occurrence, but may result in some flooding of the runway areas.

Seiches are periodic oscillations of large enclosed bodies of water which can be induced by earthquakes. They have been observed several thousands of miles from the epicenter of the inducing earthquake. The Bay Conservation and Development Commission Engineering Consultant Board noted that a rising and falling of water in the bay were reported to have accompanied two earthquakes in 1854 and one in 1856 (11). It is probable that a seich in San Francisco Bay could only be damaging in the event of a large magnitude quake and the "right" combination of tides and winds.

EXHIBIT F-5

San Francisco International Airport

AREAS OF TSUNAMI RUNUP



Source Reference (9)

5. IMPACT ASSESSMENT

As has been indicated earlier, an airport is a responder to, rather than an inducer of geological phenomena. But, the ability of the facility to operate functionally can play a major role in setting up and maintaining relief operations. In the 1972 report (12), prepared for the U.S. Office of Emergency Preparedness, the National Oceanic and Atmospheric Administration found that in the event of a major earthquake on the San Andreas Fault, the expected damage patterns would be:

- A magnitude 8.3 shock would close SFIA for a period of weeks. (Metropolitan Oakland International, Alameda Naval Airbase and Hamilton Air Force Base would be shut down for less than a week.) Practical land access would be cut off due to highway damage.

- A magnitude 7.0 earthquake would close SFIA for several days. (Others would be operational shortly after.)

A major earthquake on the Hayward fault would be expected to have the following results:

- An 8.3 magnitude shock would close down SFIA for less than a week (Metropolitan Oakland International and Alameda Naval Airbase would be nonoperational for a period of weeks. (Hamilton Air Force Base would be operational within a week.)

- A 7.0 earthquake would not close down SFIA (MOIA and ANA would be closed for several days.)

- A 6.0 shock would delay operations for only a few hours.

This performance estimate was certainly confirmed by the 1957 experience. In developing the airport according to the expansion program, there are no elements which would appreciably change this assessment. The structures to be constructed under the expansion program will incorporate design and engineering principles consistent with current design philosophy which is to minimize life hazard and to limit property damage in the event of a great earthquake. As such the structures built under the expansion program will reflect advances in the state-of-the-art which may mitigate the effects of an earthquake on them compared to older structures.

In the unlikely event of a large tsunami inundating the airport, the extended portion of runway 28R would likely be flooded.

REFERENCES

1. Goldman, H. "Geology of San Francisco Bay". Geologic and Engineering Aspects of San Francisco Bay Fill, California Division of Mines and Geology, Special Report 97, 1969.

2. Goldman, H. Ibid, p. 15

3. Treasher, R.C., Geology of Sedimentary Deposits in San Francisco Bay, California, California Division of Mines and Geology, Special Report 82, 1963.

4. Lee & Praszker, Soil and Foundation Exploration, Proposed Expansion of San Francisco International Airport. Airport Bond Fund, 1967. North and South Terminals, Rotundas and Connecting Corridors, April 21, 1968.

5. Lee & Praszker, Ibid, p. 27, Diagram 3

6. Lee & Praszker, Ibid, p. 2

7. Seid, H.B., "Seismic Problems," Geologic and Engineering Aspects of San Francisco Bay Fill, California Division of Mines and Geology, Special Report 97, 1967.

8. National Oceanic & Atmospheric Administration, A Study of Earthquake Losses in San Francisco Bay Area, U.S. Department of Commerce, 1972.

9. U.S. Department of Interior, Geological Survey, Map Showing Areas of Potential Inundation by Tsunamis in the San Francisco Bay Region, California, 1972.

10. U.S. Department of Interior, Ibid

11. BCDC Board of Consultants, The Safety of Fills, California Division of Mines and Geology. Special Report 97, 1969.

12. National Oceanic Atmospheric Administration, loc. cit., p. 169-170.

APPENDIX G

OTHER ISSUES

APPENDIX G

OTHER ISSUES

In general, when the facilities at an airport are expanded to accommodate rising levels of activity, the most controversial issues associated with such a program relate to its impact on community noise exposure, and air and water quality and roadway congestion on and near the airport. In the Bay Area too, these issues have been of paramount community concern during the planning of the SFIA terminal complex expansion, and therefore, they have been thoroughly discussed in earlier appendices of this EIAR.

However, an airport expansion program may also have potential for other types of environmental impacts.

1. INTRODUCTION

This appendix explores the impact of the proposed SFIA terminal complex expansion program in each of the following subject areas:

- Aesthetics
- Fuel and Energy
- Bay Fill
- Hydrology
- Solid Wastes
- Wildlife
- Recreational Sites
- Historical Sites

Where possible, expert opinion on these matters was solicited from the appropriate public agency. In other areas, the available literature was surveyed, and the impacts were derived from this data base.

2. AESTHETICS

The aesthetic character of an airport is really defined by the visual impressions that are made by four elements of the airport.

- The airport buildings
- The general layout of the airport within its boundaries
- The peripheral area surrounding the airport
- The approaches to the airport

These elements are viewed differently by the four principal segments of the population that interface with the airport. These affected publics are:

- The nearby communities, especially those with a residential character
- Passengers
- Employees
- Visitors

Therefore, the planning and design of the airport should reflect understanding of what is visually pleasing to the various affected publics and a maximum effort to protect and enhance features that are the source of visual pleasure even as the functional capacity of the airport is expanded

and its overall efficiency is improved. In the following, the aesthetic impact of the expansion program will be assessed with this philosophy in mind. Specifically, the issues of overall design, scenic vistas and sense of open space are addressed.

(1) Overall Design

Since its inception, SFIA has traditionally been a fully developed aviation complex. The proposed expansion program will complete this concept. When finished the North Terminal and parking garage will provide an improved symmetry of overall design, and the entire complex will provide an aspect of an integrated whole. Moreover, the buildings have been designed to be architecturally compatible with the current airport terminal buildings. The new rotundas and connecting corridors are designed to be primarily functional so as to facilitate the transfer of passengers between areas of the terminal complex. The overall design compatibility and integrity is to be achieved by placing the architectural responsibility for the entire expansion program under the aegis of a single firm.

(2) Scenic Vistas

The airport area has not been provided with a particularly advantageous viewpoint for vistas of San Francisco Bay. The San Francisco Bay Plan, developed by the Bay Conservation and Development Commission (BCDC) in 1969, identified only one vista point, at Point San Bruno, for possible development in the area of the airport (1). An easterly view toward the bay from this point would not include the airport. (Recreation uses are discussed in Section 8 of this appendix.) Direct visual access to the bay is inhibited not only by the airport, but more importantly by the local topography, the road and railway systems cutting through the area, as well as the build-up of the surrounding communities themselves. If the expansion program is undertaken the scenic view available to those outside the airport should not suffer serious deterioration since the development under the expansion program will take place within the confines of the present airport.

(3) Open Space

It is undeniable that the proposed expansion program will increase the volume of space occupied by steel and concrete within the airport, and thereby reduce any sense of open space which may presently exist. But since the airport buildings are to be only three

stories high, they should not have an appreciable detrimental effect. The expansion program does provide for $850,000 for landscaping by plantings of trees and shrubs primarily along the main access, which should enhance the general aesthetic character of the airport.

(4) Impact Assessment

In summary, the aesthetic impacts of the proposed development are:

- Fulfillment of the overall design concept resulting in an airport complete with improved symmetry and architectural integrity
- Little further deterioration of already impaired scenic views
- Limited reduction in sense of open space

On the other hand, if the proposed development plan were not implemented, the airport would remain in semi-finished condition. The situation would be unacceptable not only from an aesthetic point of view but also for functional reasons.

To assure that the proposed development does not have an adverse aesthetic impact, the following measures form part of the development plan:

- Architectural responsibility for the entire project is to be under the control of a single firm

- Significant amounts of money have been budgeted to provide for beautification of the airport and its access roadway system

  - Two million dollars ($2,000,000) has been allocated for art enrichment

  - Eight hundred and fifty thousand dollars ($850,000) has been allocated for landscaping

It would seem reasonable to conclude, therefore, that the proposed SFIA development poses no serious threat to the aesthetics of the area and could even result in enhancement of the visual pleasure that users and neighbors will derive from the airport.

3. FUEL AND ENERGY

This section presents an assessment of the energy impact of the proposed SFIA development. The impact is examined in terms of the consumption of aviation fuels, natural gas and electrical power for operation of facilities, and gasoline for vehicular traffic accessing the airport.

Fuel and energy consumption levels are determined for 1982 and 1990 under two different assumptions (i.e., with and without the proposed development) and compared with the 1974 base year. These projections were made in order to quantify the impact of the proposed improvements.

(1) Aviation Fuels

Total consumption of aviation fuel at the airport during 1973 was approximately 628 million gallons (MGY) based on information obtained from SFIA engineers (2). During that year, there was a total of 352,241 aircraft operations carrying some 15.6 million on and off air passengers (MAP). This corresponded to approximately 34 gallons of fuel per passenger or 1,783 gallons per operation.

Whether or not the proposed improvements are carried out, it is projected that in 1982 there will be 367,640 total operations with 24.4 on and off MAP. These projections represent an increased operations load of 10 percent over 1974, but the number of passengers served will have increased by about 50 percent. Two important factors will be responsible for this development.

- Higher load factors
- Greater utilization of wide body commercial jet aircraft

Indeed, in 1982, based on the fleet mixes presented in Appendix A, Exhibit A-7, there will be more than 3.75 times as many operations with wide body aircraft as there were in 1974.

Total operations for the design year 1990 are projected to decrease from 1982 by less than 2 percent to 361,340. However, the

number of passengers to be transported will have increased to 31 MAP on and off corresponding to a 29 percent increase over 1982 and about double the passenger volume of 1974. As in the case of 1982, the increased number of air passengers will be carried by more wide body type aircraft. For 1990, wide body operations will increase to 133,000, an increase of 24 percent over 1982.

In order to project aviation fuel usage for future years, a method has been developed by the Port Authority of New York and New Jersey.[1/] The method is based on calculating the total weight of the commercial aircraft utilizing an airport for any given year and comparing this value with total commercial aircraft weight for a year for which fuel consumption is known according to the following formula:

$$F_F = \frac{W_F \times F_G}{W_B}$$

1/ Joseph J. Windisch, Staff Economics Analyst, Aviation Economics Division, Aviation Department, The Port Authority of New York and New Jersey.

Where,

F_F = aviation fuel consumption for forecast year

W_F = total weight of commercial aircraft based on fleet mix for forecast year

F_B = aviation fuel consumption for base year

W_B = Total weight of commercial aircraft based on fleet mix for base year

For airports such as SFIA, with large commercial components, predictions of fuel consumption within 10 percent of actual usage can be made. Exhibit G-1, on the following page, presents the estimated aviation fuel consumption at SFIA for the years 1974, 1982 and 1990. As can be seen from the exhibit, projected aviation fuel consumption will increase by 21 percent and 30 percent for the years 1982 and 1990, respectively. On a gallons per passenger basis, however, there is a decrease of 21 percent and 31 percent for 1982 and 1990 in comparison to 1973 consumption. The results are summarized in the table below:

Per Passenger Aviation Fuel Consumption

Year	Gallons Per Passenger	Percent Decrease
1974	36	-
1982	29	21
1990	25	31

EXHIBIT G-1
San Francisco International Airport
PREDICTED AVIATION FUEL CONSUMPTION

Year	Commercial Aircraft Weight[1/] (HMP)	Aviation Fuel Consumption[2/] (MGY)	Increase In Consumption Over 1974 (%)
1974	636	587	-
1982	907	711[3/]	21
1990	973	763[3/]	30

HMP = Hundred million pounds
MGY = Millions of gallons per year
NA = Not applicable

1/ Based on fleet mix data given in Appendix A and Reference (3)

2/ Calculated estimates of fuel consumption using base year 1973 data supplied by SFIA Engineers (2)

3/ Estimates values for 1982 and 1990 have been decreased by 15% to allow for engine efficiency improvements

Note: Aviation fuel consumption for 1971 was "back calculated" to demonstrate the accuracy of the prediction methodology (estimated value was within 10% of actual fuel consumption)

Source: Landrum & Brown

The reduction in per passenger consumption of fuel can be attributed to the operation of higher efficiency aircraft, i.e., the new wide body types of aircraft.

In summary, although there will be a significant increase in fuel consumption for the years 1982 and 1990 over 1974 (21 and 30 percent, respectively) at SFIA there will be a corresponding increase in the efficiency of fuel used due to the utilization of wide body commercial jet aircraft[1/].

(2) Natural Gas for Terminal Heating

The existing Central and South Terminals are heated by natural gas. The heating plant for the two terminals is located in the south building. Natural gas is distributed to SFIA and to its tenants by the Pacific Gas and Electric Company (PG&E). As a general practice, all gas main work is performed by the utility company.

The airport property is served from two primary supply connections to the 20-inch pressure transmission main which parallels by the Bayshore Freeway.

1/ In an era of energy shortgages and high energy costs, this statement touches upon a subject of great concern. However, it may well be irrelevant to the decision to proceed or not to proceed with the SFIA terminal complex expansion since these increases in traffic are anticipated to occur regardless of the terminal expansion.

- The cargo and terminal areas are served from a 6-inch connection to the 20-inch main west of Bayshore Freeway opposite the airport entrance road.

- The United Airlines Maintenance Base and the north area of the airport are served from connections to the 20-inch main in South Airport Boulevard near San Bruno Avenue.

A new 8-inch main has been constructed by PG&E to serve future development in the north area.

Data obtained from PG&E for natural gas consumption at this plant for the time period of April 1972 through April 1974 shows that on average, about 138 million cubic feet per year (MCFY) of natural gas were consumed there.

The ultimate airport expansion involves the construction of a new North Terminal, and additions to the Central and South Terminals. An element of the expansion program is a new integrated heating plant which service all the terminal buildings. This plant will be located in the Ground Transportation Center.

Based on a 1970 report by Metcalf & Eddy, Inc. (4), and estimates by SFIA engineers, concerning necessary additions and improvements in the natural gas distribution system due to proposed airport expansion, and the annual consumption data presented above, it is anticipated that the improved terminal complex will

require an additional 210 MCFY per year for heating. This would raise consumption to approximately 350 MCFY. This increase in natural gas consumption for heating appears reasonable due to the increase in the size of the terminal facility. The estimated consumption of natural gas at SFIA for the development alternatives under consideration here are presented in Exhibit G-2, following this page.

According to PG&E (5), customers using in excess of 1.2 million but less than 24 million therms per year [1/], can expect to have their gas service interrupted due to shortages as follows:

Heating Season	Percent Interruption of Service[2/]
1974-1975	1
1975-1976	5
1976-1977	12

Source: PG&E

In order to prevent a shutdown of the heating plant due to an interruption in gas supply, the present and proposed plants are designed to use fuel oil when necessary.

1/ 1 Therm = 100,000 BTU's

2/ Assuming a normal winter

EXHIBIT G-2
San Francisco International Airport
NATURAL GAS CONSUMPTION AT SFIA

Year	Airport Configuration	Natural Gas Consumption (MCF)
1974	Present	138
1982	No further development	138
	Project	350
1990	No further development	138
	Project w/BART	350
	Project w/o BART	350

MCF = Millions of cubic feet

Source: Landrum & Brown

(3) Electric Power Consumption at SFIA

Electric power is supplied to the airport by PG&E by means of high voltage transmission lines from several major hydroelectric and thermal electric generation facilities. The Millbrae and "BA" substations service the airport with three 12-kv feeders; which have no other loads. According to the Master Utilities Plan (6), the loss of one of the three incoming 12-kv sources of supply to the airport under current (1971) peak load conditions will not require the dropping of any loads. In regard to further peak loads, the shedding of lower priority loads could be required during some further peak load periods in the unusual circumstance that one of the PG&E substations were out of service.

The same Master Utility Plan provided for an ultimate load of 90 M VA, as had been recommended in an earlier plan (7), however, the time of realization of this ultimate load could not be predicted. Subsequent developments indicate that this estimate is probably too high for the planning period of this study.

During 1974, the average demand for electric power was about 15.3 megawatts (8). The airport engineers and airport consultants indicate that this average power demand is fairly constant during the day, and probably does not vary by more than 10 percent

between night and day. On this basis, one may estimate the current daily electrical energy consumption to be about 370 megawatt hours, or 135 million kilowatt hours. By comparison, the total energy produced by PG&E and other suppliers in the forty-eight county area amounted to 67,329 million kilowatt hours (9). Therefore, electrical energy consumption at SFIA amounted to less than one-half of one percent of the regional consumption.

The expansion program involves construction of a new North Terminal, and expansion of the present South and Central Terminals, as well as the expansion of the garage and construction of the industrial waste treatment plant. It is difficult to estimate with great accuracy, the power demand of a complex as complicated as SFIA. However, it is clear that these elements will significantly increase the electric power consumption at the airport. The increments to the present electrical energy consumption are derived from estimates of electrical demand prepared by the airport consultants and are shown in Exhibit G-3, on the following page (10). Even in the no further development alternative, there will be about a 25 percent increase in electrical energy consumption because of projects which are not a part of the expansion program. The increase in electrical energy consumption is due primarily to the additional lighting load for the expanded terminal complex, and

EXHIBIT G-3
San Francisco International Airport
ELECTRICAL POWER CONSUMPTION AT SFIA

Year	Configuration	Electrical Energy Consumption (Mkwh)
1974	Present	135
1982	No further development	170
	Project	630
1990	No further development	170
	Project w/o BART	630
	Project w/BART	640

Source: Landrum & Brown

also to the installation of air conditioning throughout the public area of the terminal. It should be pointed out that even under the expansion program SFIA would continue to consume less than 1 percent of the electrical energy currently consumed in the forty-eight county service area. Linking SFIA to the present Daly City terminal of the BART aystem would increase electrical energy consumption less than 2 percent.

(4) Gasoline for Airport Related Vehicular Traffic

Persons coming to SFIA do so primarily on the Bayshore Freeway; secondary routes are along El Camino Real, and the secondary streets in the neighboring communities. When the Interstate 380 - U.S. 101 interchange is completed, Interstate 280 should also experience increments in airport related traffic. An additional element in considering traffic generated fuel requirements is the proposed mass transit link between Daly City and SFIA. In Appendix C of this report, detailed analysis of the miles traveled by motor vehicles accessing the airport was undertaken. From this data base, estimates of fuel consumption required by this traffic pattern can be derived. The results of the analysis are summarized in Exhibit G-4, on the following page. In essence the results are:

- Current fuel consumption during the 1974 planning year amounted to 66 million gallons of gasoline (MGY).

Year	Airport Configuration	Annual VMT (MMY)	Fuel Consumption[1/] (MGY)
1974	Existing	657	66
1982	No Further Development	1132	78
	Proposed Project	1132	78
1990	No Further Development	1808	80
	Proposed Project Without BART	1808	80
	Proposed Project With BART	1497	75

VMT = Vehicle Miles Traveled
MGY = Millions of Gallons Per Year
MMY = Millions of Miles Per Year

1/ Based on the following gasoline engine efficiencies
- 1974 -- 10 miles per gallon
- 1982 -- assuming an overall 50% increase in engine efficiencies over 1974
- 1990 -- assuming an overall 100% increase in engine efficiencies over 1974

Note: Excludes service vehicles which consume less than 1 percent of vehicle consumed fuel

Source: Landrum & Brown

EXHIBIT G-4
San Francisco International Airport
VEHICLE GASOLINE CONSUMPTION

- In the 1982 planning year, motor vehicle fuel consumption will increase about 18 percent to about 78 MGY regardless of whether the expansion program is undertaken. The increase in fuel consumption is significantly less than the increase in VMT (72 percent) on the assumption of improved engine efficiency.

- In 1990, the fuel consumption by motor vehicles will depend on whether the proposed mass transit link is accomplished.

  - Without such a system, fuel consumption should increase about 21 percent over 1974 levels to about 80 MGY.

  - With mass transit, the increment over 1974 consumption levels will be about 14 percent to 75 MGY, and about 6 percent less than 1990 levels without the system.

(5) Energy Impact Assessment

The energy impacts associated with activities at SFIA in future years, (both with and without the proposed development) are summarized below.

- Whether or not the airport development plans are carried out, total aircraft operations at SFIA will increase to 367,640 with an expected 24 MAP in 1982. For 1990, there will be 361,340 operations with 31 MAP. The increases in aviation fuel usage are projected to result in total energy consumption by aircraft of:

  - About 89 trillion BTUs in 1982[6/].

  - About 96 trillion BTUs in 1990.

6/ 1 trillion BTUs = 1×10^{12} BTUs

- In the no further development alternative, energy consumption at the airport for operating of facilities will increase about 25 percent due to normal non-expansion program development in the electrical power sector. With the expansion program, the increased requirement for natural gas for heating will result in raising the energy consumption by a factor of about two and one-half to slightly more than one-third trillion BTUs from the current consumption level of 0.15 TBTUs. Increased requirements for electrical power for lighting, air conditioning and other facility operations will increase energy consumption by a factor of about 5 to 2.15 TBTUs per year. The current consumption is about one-half TBTUs per year for this sector. In the event of a mass transit link between SFIA and Daly City, the increased energy consumption for moving the less than 20 percent of the anticipated passengers by this mode would increase energy consumption by less than 2 percent.

- Fuel consumption for airport related vehicular activity may be summarized as follows:

  - 1982 - 8.7 trillion BTUs

  - 1990 - with BART - 8.6 trillion BTUs, all other cases 9.2 trillion BTUs

The use of BART coupled with more efficient gasoline engines will lessen the impact of the expected increase in VMT due to the rising volume of air passengers at SFIA through 1990.

Exhibit G-5, on the following page, summarizes the impact on energy due to increases in demands for aviation fuels, natural gas for terminal heating and gasoline for vehicular traffic.

FUEL AND ENERGY CONSUMPTION (TBY)

Year	Airport Configuration	Aviation Fuel	Natural Gas	Electrical	Automotive Gasoline	Total	Increase Over 1974 %
1974	Existing	74	0.15	0.5	7.6	82.2	-
1982	No further development	89	0.15	0.6	8.7	98.4	20
	Proposed project	89	0.35	2.1	8.7	100.2	22
1990	No further development	96	0.15	0.6	9.2	105.9	29
	Proposed project Without BART	96	0.35	2.1	9.2	107.7	31
	Proposed Project With BART	96	0.35	2.2	8.6	107.2	30

TBY - Trillion BTUs per year

Source: Landrum & Brown estimates

EXHIBIT G-5
San Francisco International Airport
SUMMARY OF ENERGY IMPACT

4. BAY FILL

San Francisco Bay is an irreplaceable gift of nature that serves both human and natural needs, and is a unique asset to the Bay Area. The Bay needs to be protected from needless and gradual destruction by water pollution, or developments which require filling or extraction of its resources. Any of these activities must be carefully justified before they are allowed to impact on the Bay.

According to the Bay Conservation and Development Commission (11), the state agency responsible for Bay development and protection, some Bay filling may be justified for purposes providing substantial public benefits if these benefits could not be achieved equally well without filling. Substantial public benefits are provided by developing expanded airport terminals and runways if regional studies demonstrate that there are no feasible sites for major airport development away from the Bay. The Regional Airport Systems Study (12) has recommended the expansion of SFIA as contemplated by the airport's expansion program.

Bay filling is not an element of this expansion program. The preliminary plan included filling of the Seaplane Harbor and providing roads and facilities in this area. This element has been removed from the expansion program.

5. HYDROLOGICAL CONSIDERATIONS

The additional terminal facilities planned or under construction will not significantly affect the hydrological conditions at the site.

There is no pumping of ground water for any supply purpose, nor is there any planning for such pumping.

(1) General Characteristics of the Water Table

The water table in the airport area is approximately 5 feet above sea level in wet winter months and drops several feet during the dry summer months. The exact amount of drop during summer months has not yet been accurately determined. The water table is above mean sea level for the following reasons according to a study by Lee and Praszker (13).

- The fill which is superimposed upon the Upper Bay mud tends to increase the pore water pressure in the mud by virtue of its weight, so that the water is forced to flow in all directions including upwards.

- The groundwater emanating from the hills to the west travels toward the Bay and it also courses between the interface of the fill and mud. The hydrostatic pressure which causes the water to flow forward also forces it to build up a head in the fill above the mud.

(2) Effects of New Constructions

Numerous past and ongoing airport construction projects have indicated that construction affects the water table very little. For instance, the soil in the North Terminal foundation excavation is relatively impermeable. The amount of water entering the foundation excavation was extremely small. The drawdown effect of the seepage into the excavation, although not measured, could not have been great even in the vicinity of the excavation, and would not have been discernible at any location off of the airport. Since the North Terminal foundation required as large an excavation as any of the facilities would require in the entire expansion program, the effect of the excavation on lowering the water table is expected to be negligible.

6. SOLID WASTES

Many airports across the nation are developing into major commercial complexes which have the same problems of development as other urban institutions. One of these is the disposal of the solid wastes, i.e. the metal, paper, plastic, wood and food wastes generated by human activities. SFIA is somewhat unique in its position with respect to the greater Bay Area community which surrounds it on three sides. Whereas other airports may have open land surrounding them, SFIA is itself surrounded by communities. This fact imposes more stringent requirements on it for disposing of its wastes in a manner compatible with the rest of the community.

(1) Sources of Solid Wastes

Functionally there are four major activity centers at SFIA which generate solid waste:

- The passenger terminals of which there are currently two. A new North Terminal is a part of the expansion program.
- The air freight and air mail handling facilities in two areas incorporating eight buildings
- The aircraft service centers of which there are six major areas with several buildings per area.
- The aircraft maintenance base.

An extensive survey of the solid waste system at SFIA was carried out during 1971, by Metcalf & Eddy (14). The weight and compositions of the solid wastes generated by these source activities were analyzed. The results of this analysis are shown in Exhibit G-6, on the following page. The data were further analyzed and correlated with measurable units of airport activity to give representative solid waste generation parameters:

- 0.53 pounds per passenger for the terminals.
- 7.10 pounds per ton of cargo for the air freight areas

EXHIBIT G-6
San Francisco International Airport
SOLID WASTES AT SFIA

Year	Solid Wastes at SFIA (KTPY)	San Mateo County Solid Waste[1/] (KTPY)	Percent
1974 16.5 MAP (362 KTC)	18	874	1.8
1982 24.4 MAP (997 KTC)	24	1060[2/]	2.3
1990 31 MAP (710 KTC)	30	1265	2.4

Notes:
1/ San Mateo County Planning Commission
2/ 1980 Estimate

KTC = 1000 Tons of cargo
KTPY = 1000 tons per year

Source; Landrum and Brown

- 1.02 pounds per passenger for the service centers
- 2.19 pounds per employee per day for the aircraft maintenance base.

These data have been confirmed by more recent information from the airport scavenger service which serves the airport and its tenants (15).

(2) Impact Assessment

The data generated above can be used to make projections of solid waste loads that will be generated at SFIA in the future. As has been shown earlier (Appendix A) aviation demand levels (air passengers and aircraft operations) will increase in virtually the same way at SFIA whether or not the expansion plan is implemented. Given this fact, the no further development case will impose the same requirements on the airport as well as the proposed development alternative.

The projections of future passenger and air cargo area solid waste quantities, shown in Exhibit G-6, indicate that SFIA will continue to generate about two percent of the total San Mateo county solid waste load.

Current practice is to dispose of SFIA solid waste material at the Menlo Park sanitary landfill. This site is expected to have a viable life of six to eight more years after which it is planned that it will be developed into a park. Beyond that, an additional site, Ox Mountain, is under consideration as a future development. The airport will cooperate with local and regional agencies in planning for use of alternative sites.

In addition to the wastes generated by passenger and cargo related activities, some solid waste is generated by other activities such as construction, and demolition. Wood materials from such activities are usually disposed of outside the airport in the sanitary landfill. Dirt, broken asphalt and concrete are used as landfill.

At the time of the Metcalf & Eddy study, only one airport, Sacramento Municipal Airport, conducted a formal recycling program. This program was aimed at recovery and reuse of cardboard only.

In summary, SFIA's impact on solid waste disposal should not be significantly greater than it presently is. The present solid waste load is about two percent of the county total and should remain so over the period under consideration.

7. WILDLIFE

San Francisco Bay provides an almost ideal environment for a large variety of fish and wildlife. The estuarine environment includes areas of marshlands, salt flats, mud flats and shallow open waters, and so can support this diverse population. Human benefits from the fish and wildlife from the Bay involve food, income, recreation, scientific research, education and an environment for living. Although no comprehensive estimate of the value of these benefits has been made, there is no question but that they provide substantial public benefit and must be maintained for both present and future generations of California.

(1) Habitats

Four major wildlife habitats exist in and around the Bay; approximately 50 square miles of marshland, 78 square miles of salt production lands, 65 square miles of tidal flats and 400 square miles of open water.

Marsh areas are used for nesting, feeding and protective grounds for many bird species. Major marshlands are located in Suisun Bay and around the Napa River. Smaller remnants of marshes exist around San Pablo Bay and South San Francisco Bay.

Salt production lands are important in the overall ecological picture of birds in the Bay. All species use these ponds for nesting and feeding areas. Shorebirds depend upon them for nesting areas during high tide.

Exposed mud flats and tidelands occupy major portions of the Bay, except where fill areas extend out to deep water. These tidal flats produce mussels, clams, snails, worms and insects that shorebirds depend upon for survival. They are the food store for shorebirds. The waterfowl and shorebirds use the Bay principally in areas where water is less than 18 feet deep at low tide. This generally approaches the normal feeding depth limit for most species of diving ducks. The flats and shoal areas provide a great abundance of invertebrate fauna, which comprise the main diet of many species of diving ducks and shorebirds.

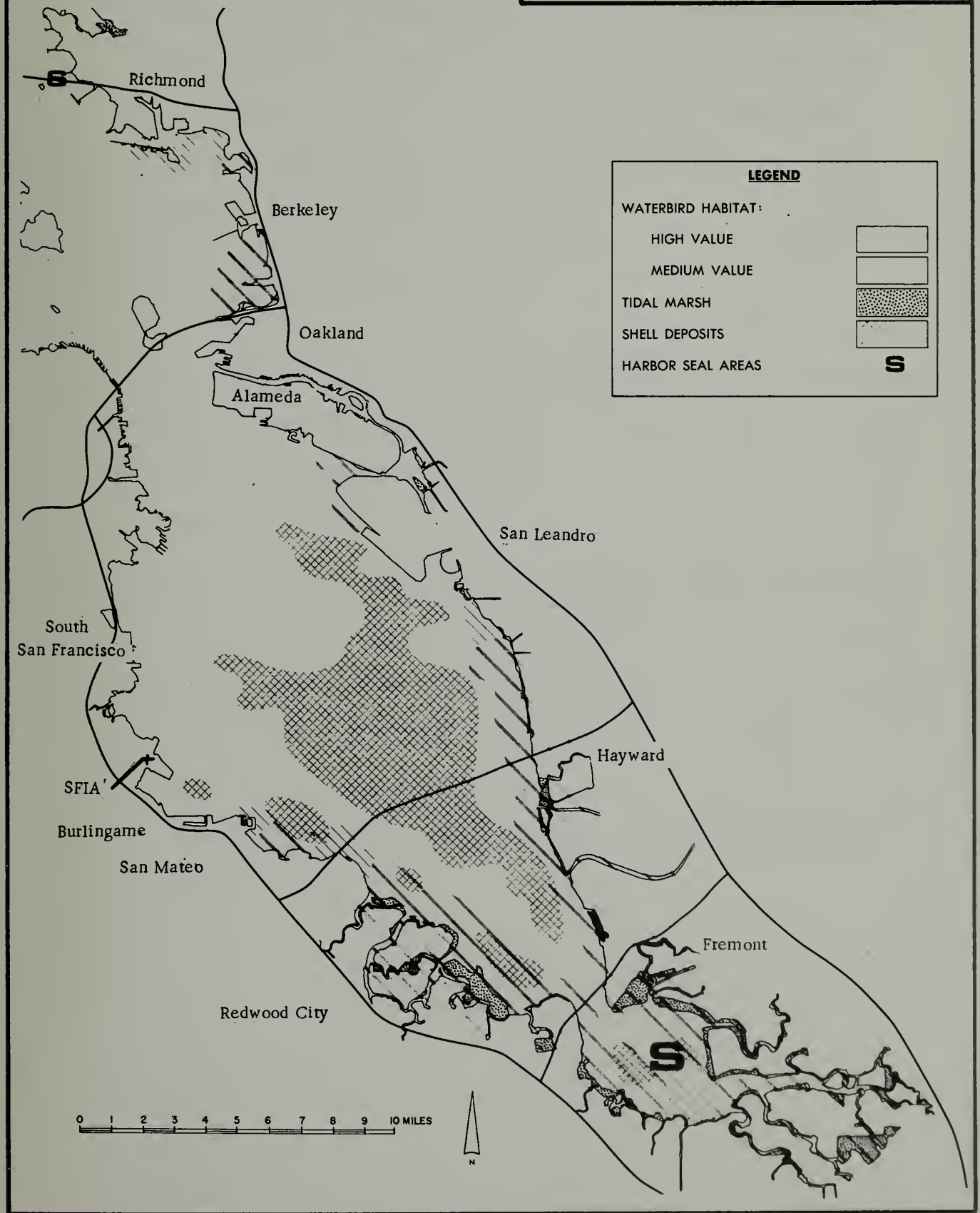
Open water areas are used by ducks, cormorants, geese and loons for nesting, and sometimes feeding areas.

The bay area is an essential nesting place, feeding area and watering ground for birds on the Pacific Flyway from Mexico to Canada. The route of the Pacific Flyway is shown as Exhibit G-7, on the following page.

EXHIBIT G-7

San Francisco International Airport
PACIFIC FLYWAY

EXHIBIT G-8
San Francisco International Airport
SAN FRANCISCO BAY IN
SAN FRANCISCO INTERNATIONAL
AIRPORT AREA



The natural resources of the bay include waterfowl habitat, shell deposits, rookeries for harbor seals and tidal marshes which are essential to the existence of numerous species of fish, birds and animals. Exhibit G-8, following G-7, shows these natural resource areas. As can be seen the area around SFIA is not regarded as prime wildlife habitat.

(2) Impact Assessment

Since the proposed expansion program is to take place within the confines of the present airport, little impact on the fish and wildlife of the Bay Area is expected. The opinion of the U. S. Department of Interior and the California Department of Fish and Game were solicited in this regard, and these agencies concur that the effects of the expansion program should be minimal. The responses of these agencies are presented here as Exhibits G-9 and Exhibit G-10. It should be noted that since it is anticipated that the number of aircraft operations is expected to decline slightly during the period under study, there should be a lessening in whatever affect may be attributed to them.

EXHIBIT G-9
San Francisco International Airport
RESPONSE OF CALIFORNIA
DEPARTMENT OF FISH AND GAME

STATE OF CALIFORNIA—RESOURCES AGENCY

Edmund G. Brown Jr.
~~RONALD REAGAN~~, Governor

DEPARTMENT OF FISH AND GAME
Post Office Box 47
Yountville, California 94599

February 19, 1975

R. F. K.
FEB 26 1975

Mr. Robert F. Kamm
c/o Foster D. Snell, Inc.
Hanover Road
Florham Park, New Jersey 07932

Dear Mr. Kamm:

Thank you for your letter requesting our review of the project description for the San Francisco Airport Expansion.

As per your meeting with Mr. Gill of my staff and subsequent discussion of the proposed project, the Department of Fish and Game does not anticipate any significant impact of the proposed expansion program on the wildlife resources and habitat of the area.

As you acknowledge, however, Department of Fish and Game will still have to review the environmental impact statement. It is possible that we might comment at that time.

We appreciate your solicitation of our comments prior to the EIS review.

Sincerely,

J. C. Fraser
Regional Manager
Region III

EXHIBIT G-10
San Francisco International Airport
RESPONSE OF UNITED STATES
DEPARTMENT OF THE INTERIOR

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
~~BUREAU OF SPORT FISHERIES AND WILDLIFE~~

1500 N. E. IRVING STREET
P. O. BOX 3737
PORTLAND, OREGON 97208

Reference: RB

January 22, 1975

Mr. Robert F. Kamm
Associate Research Director
Foster D. Snell, Inc.
Hanover Road
Florham Park, New Jersey 07932

Dear Mr. Kamm:

This responds to your letter of January 8 regarding the preparation of an environmental impact statement for the proposed expansion of San Francisco International Airport.

We agree with your conclusion that effects of the expansion on wildlife and their habitat would be minimal.

We regret we have no reports describing the impacts of increased noise and diminished air quality on wildlife as they relate to airport expansion. We presume any effects occurring now would increase as airport use increased.

Thank you for the opportunity to comment on this proposal.

Sincerely yours,

Acting Regional Director

Edward J. Smith

8. RECREATIONAL SITES

There are two aspects of recreational activity which must be addressed in evaluating the impacts of airport development:

- Use of the Bay shoreline for recreational purposes
- Use of park and playgrounds away from the shoreline

Because an airport may induce unpleasant effects at recreational sites, an investigation of these sites in relation to the airport was made in conjunction with preparation of this EIS.

In making this evaluation, the Community Noise Equivalent Level (CNEL) contours (developed in Appendix B) were used, and the location of parks in relation to the contours was determined. Although no specific criteria for parks and playgrounds are established, compatible land use for residential purposes is that lying within the contours designated 80 CNEL in 1974, 70 CNEL in 1982 and 65 CNEL contour in 1990. Location of parks and playgrounds on land compatible for residences is certainly a compatible land use.

(1) Bay Shoreline Recreational Areas

The Bay shore area provides sites for many recreational activities including fishing, boating, biking and general recreation. The San Francisco Bay Plan developed by the Bay Conservation

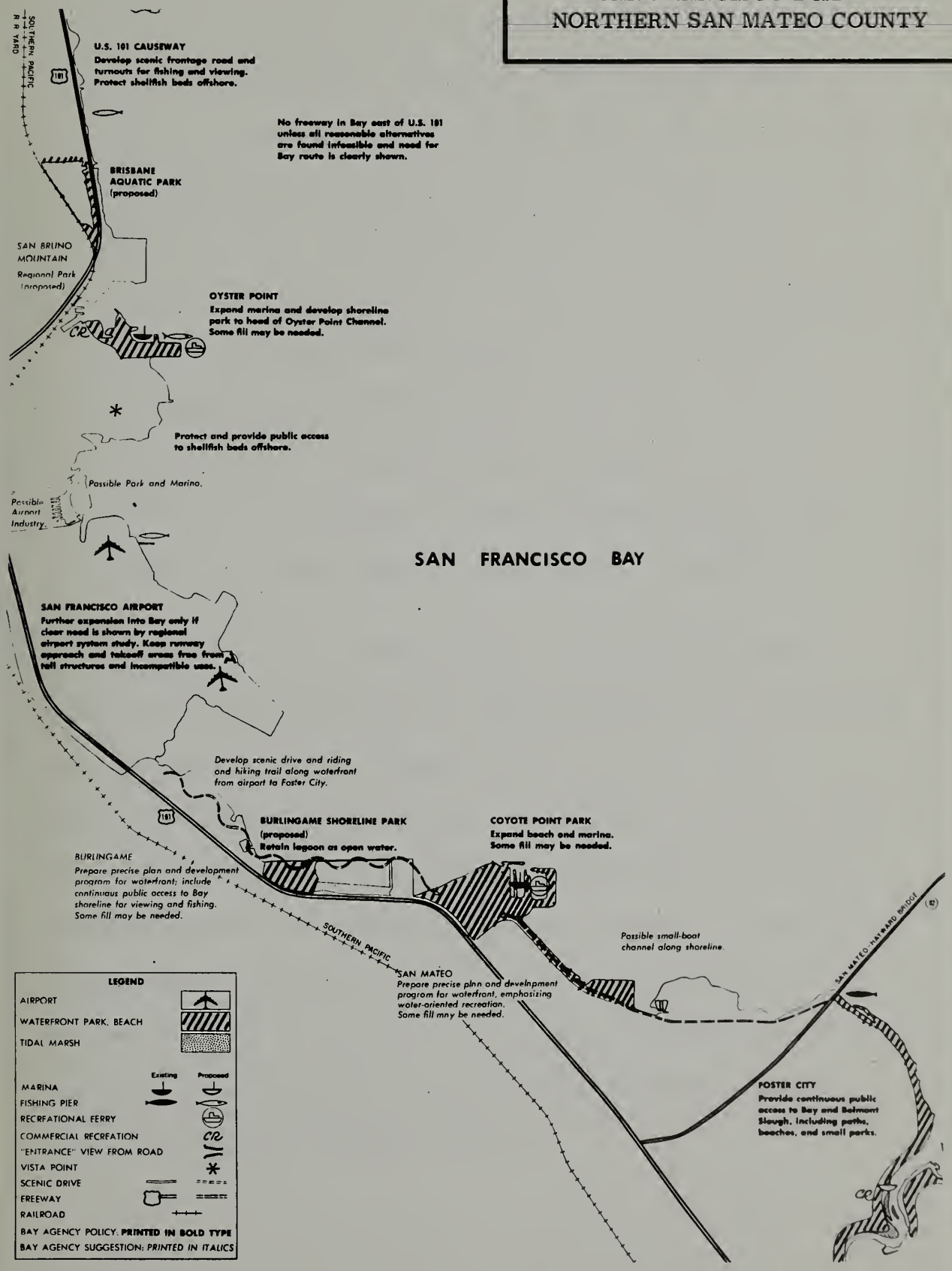
and Development Commission (BCDC) recommends that access to the Bay shore be made readily available for recreational uses. The sites which the plan proposed for recreational use in the area of SFIA are shown in Exhibit G-11, on the following page, Development of the airport under the expansion program will not jeopardize the existence of any of these sites. In comparing the location of these sites with the noise contour, one finds that only the Oyster Point park and marina area may fall within 1990 65 CNEL contour during the weather imposed period when operations require use of runways 28R and L and 20R and L for all landings and take-offs. For all other scenarios, the Bay shore parks do not lie within the contours compatible with residential use for the given time period.

It should be noted that the airport itself is a source of recreational enjoyment for many people who enjoy viewing airport activity from the undeveloped land along the Old Bay shore highway. The activity will not be hindered by the expansion program.

(2) Parks and Playgrounds

Since the airport expansion projects will be carried out within the bounds of the present airport, they do not threaten the existence of any of the parks in the area. With regard to inland parks, parks and playgrounds within the communities of South San Francisco

EXHIBIT G-11
San Francisco International Airport
SAN FRANCISCO BAY
NORTHERN SAN MATEO COUNTY


SOUTHERN PACIFIC R R YARD
U.S. 101 CAUSEWAY
Develop scenic frontage road and turnouts for fishing and viewing. Protect shellfish beds offshore.
No freeway in Bay east of U.S. 101 unless all reasonable alternatives are found infeasible and need for Bay route is clearly shown.
BRISBANE AQUATIC PARK (proposed)
SAN BRUNO MOUNTAIN Regional Park (proposed)
OYSTER POINT
Expand marina and develop shoreline park to head of Oyster Point Channel. Some fill may be needed.
Protect and provide public access to shellfish beds offshore.
Possible Park and Marina.
Possible Airport Industry.
SAN FRANCISCO BAY
SAN FRANCISCO AIRPORT
Further expansion into Bay only if clear need is shown by regional airport system study. Keep runway approach and takeoff areas free from tall structures and incompatible uses.
Develop scenic drive and riding and hiking trail along waterfront from airport to Foster City.
BURLINGAME SHORELINE PARK (proposed)
Retain lagoon as open water.
COYOTE POINT PARK
Expand beach and marina. Some fill may be needed.
BURLINGAME
Prepare precise plan and development program for waterfront; include continuous public access to Bay shoreline for viewing and fishing. Some fill may be needed.
SOUTHERN PACIFIC
Possible small-boat channel along shoreline.
SAN MATEO
Prepare precise plan and development program for waterfront, emphasizing water-oriented recreation. Some fill may be needed.
SAN MATEO-HAYWARD BRIDGE
POSTER CITY
Provide continuous public access to Bay and Belmont Slough, including paths, beaches, and small parks.
LEGEND
AIRPORT
WATERFRONT PARK, BEACH
TIDAL MARSH
Existing
Proposed
MARINA
FISHING PIER
RECREATIONAL FERRY
COMMERCIAL RECREATION
"ENTRANCE" VIEW FROM ROAD
VISTA POINT
SCENIC DRIVE
FREEWAY
RAILROAD
BAY AGENCY POLICY: PRINTED IN BOLD TYPE
BAY AGENCY SUGGESTION: PRINTED IN ITALICS

and San Bruno, are within the contours under certain scenarios. In 1974, no parks are within the 80 CNEL contour. In 1982, no parks or playgrounds are within the 70 CNEL annual average contour. Although, the park on Seventh Avenue in San Bruno will be within the contour during the May and June seasonal period. In 1990, five parks, two in San Bruno on Seventh and Huntington Avenues, and three in South San Francisco, including the California Golf Club, the playground on Spruce Avenue and the park on Granada Drive are within the 65 CNEL contour, but outside the 70 CNEL contour. During the May and June period of weather affected aircraft operations, the Oyster Point park area also falls within the 65 CNEL contour, but lies outside the 70 CNEL contour.

In summary, for the planning years 1974 and 1982, no parks or recreation areas fall within the land areas incompatible for residential use (save one which may do so during the seasonal period). In 1990, six parks will, at times, fall within the contour then applicable to residential use. It should, however, be emphasized that these same parks will be on land which has been compatible with residential use for the previous planning years. The implication of this is that by 1990, the use of residential criteria to assess recreational land use becomes too conservative. Obviously, the use of land for recreational purposes need not have as strict a requirement as residential land use.

9. HISTORICAL SITES

The Bay area has many sites of historical interest. People should be able to inspect and study these in reasonable comfort and convenience. Since airports may generate undesirable effects outside their boundaries, an investigation of the possible impact of the SFIA expansion program on the historical sites in the area was undertaken in conjunction with preparation of this EIS.

In making this evaluation, the California Community Equivalent Noise Level (CNEL) contours (developed in Appendix B) were used, and the location of a given site in relation to the contour was determined. Although no specific criteria for historic sites are established, compatible land use for residential purposes is that having a 80 CNEL in 1974, 70 CNEL in 1982 and CNEL in 1990. Location of historic places in residentially compatible areas should certainly impose no hindrance on the enjoyment and study of them.

(1) Historical Sites

The California Department of Parks and Recreation maintains lists of sites of historic interest. Those in the area of SFIA are described in Exhibit G-12, on the following page (2). The airport itself is not currently listed on any list of historic places.

EXHIBIT G-12
San Francisco International Airport
RESPONSE OF DEPARTMENT
OF PARKS AND RECREATION

STATE OF CALIFORNIA—THE RESOURCES AGENCY EDMUND G. BROWN JR., Governor

DEPARTMENT OF PARKS AND RECREATION
P.O. BOX 2390
SACRAMENTO 95811

March 6, 1975

Mr. Robert F. Kamm
Associate Research Director
Foster D. Snell, Inc.
Hanover Road
Florham Park, New Jersey 07932

Dear Mr. Kamm:

In compliance with your telephone conversation of February 26, 1975, requesting information regarding historical properties identified on State and Federal register programs in the general vicinity of the San Francisco International Airport, San Mateo County, we submit the following information.

The San Francisco Bay Discovery Site, four miles west of San Bruno via Skyline Drive and Sneath Lane, is on the National Register of Historic Places.

The following are California State Historical Landmarks: No. 48 De Anza's Campsite in Burlingame; No. 47 De Anza's Expedition Campsite in San Mateo; No. 393 Hospice of Delores Mission Site in San Mateo; and No. 846 the Burlingame Railroad Station in Burlingame.

The following are California Points of Historical Interest: No. 16 Tanforan Rack Track Site in San Bruno; No. 18 Templeton Crocker Home "Uplands", 400 Uplands Drive in San Mateo; No. 20 W. J. Martin Home, Eucalyptus and Grand Avenue in South San Francisco; and No. 26 Sunshine Cottage, 141 Borel Avenue in San Mateo.

Please feel free to contact this office should you require further assistance regarding this matter.

Sincerely,

R W Porter

Russell W. Porter, Chief
Grants and Statewide Studies Division

L-4a/1

(2) Impact Assessment

Since the airport expansion program will take place within the confines of the present airport, the existence of none of these sites is jeopardized by the program.

With respect to noise exposure, only California Points of Historical Interest

- #16 Tanforan Race Track, San Bruno
- #20 W.J. Martin Home, "Upland," South San Francisco

are on or within the 1974 season 65 CNEL contour. Refer to Exhibit B-19. The Martin Home (#20) is barely within the 65 CNEL contour. Compared to the annual contour, the site is well outside the contours. The Tanforan Race Track site (#16) is between the 65 and 70 CNEL contours for both seasonal and annual conditions. It should be noted that this site has been transformed into a shopping center, and is consequently within a compatible land use designation.

By 1982, only the former race track site will be within the contours, remaining within the 65 CNEL contour. This situation will continue to occur in the 1990 planning year.

In summary, the airport, even in its present configuration, has little impact on historical sites. In the 1982 and 1990 planning year, since the noise contours are shrinking due to reduced operations, this situation is improved to the extent that no preserved site is within any of the contours.

REFERENCES

1. Bay Conservation and Development Commission, The Bay Plan, 1969.

2. SFIA Engineers to Metropolitan Transportation Commission, Private Communication, November 13, 1974.

3. The Port Authority of New York and New Jersey, Maximum Allowable Landing and Take-off Weights of Aircraft Used Certificated Scheduled Air Carriers at Port Authority Airports, 1975.

4. Metcalf & Eddy, Inc. Report to the City and County of San Francisco Airport Commission on Addition and Improvements to the Water, Sewage, Drainage and Gas Systems for San Francisco International Airport, 1970.

5. Pacific Gas and Electric Company, Gas Supplies Forecasts, July, 1974.

6. R. W. Beck & Associates, Master Utilities Plan and Electrical Systems Study, at San Francisco International Airport for Airport Commission, City and County of San Francisco, 1972.

7. R. W. Beck & Associates, Ibid. Appendix.

8. SFIA Engineers to Landrum & Brown, Private Communication, March 28, 1975.

9. Pacific Gas & Electric Company, Prospectus First and REfunding Mortgage Bond Series 74A 1974, p. 15.

10. Buonaccorsi & Associates to San Francisco Airport Architects, Private Communication, March 31, 1975.

11. Bay Conservation & Development Commission loc. cit.

12. Regional Airport Systems Study Committee, Regional Airport Systems Study, Final Plan, 1972.

13. Lee & Praszker, Soil and Foundation Exploration Proposed Expansion of San Francisco International Airport, Airport Bond Fund, 1967, April 21, 1969.

14. Metcalf & Eddy, Inc. Report on Analysis of Airport Solid Waste and Collection Systems, 1972.

15. South San Francisco Scavenger Company, Private Communications, January 1975.

16. San Mateo Planning Commission, Private Communication, January 1975.

APPENDIX H

ANALYSIS OF BENEFITS AND COSTS

APPENDIX H

ANALYSIS OF BENEFITS AND COSTS

The Airport's Commission, San Francisco International Airport, has undertaken an airport development program designed to accommodate forecast air transportation demand in the Bay Area through 1990. The elements of this program have been described in Chapter I of this report. The Airport's Commission has recognized that this airport development action will have effects upon the environment and in consistency with the National Environmental Policy Act (NEPA), this Environmental Impact Assessment Report (EIAR) has been prepared to describe those effects and to identify measures for the mitigation of potentially adverse effects. Previous sections of this report have treated many of these topics such as air and noise pollution effects.

The purpose of this appendix is to describe the analyses of benefits and costs associated with the proposed project. Subsequent paragraphs will describe the scope of the analyses, the methodologies used, and the findings made.

1. INTRODUCTION

Since the preparation of the RASS and the adoption of recommendations by the MTC, significant changes have occurred in the national economy. Notable among these are the energy crisis and concomitant spiralling price of oil, a seemingly inexorable climb in consumer and wholesale price indices and the economic downturn of 1974 with associated increases in unemployment. The

effects of worsened economic conditions have permeated most sections of the economy and air travel has not been excepted. Growth in air transportation demand has slowed and, as a result, significant questions have been raised concerning the effects of this reduced rate of growth upon the recommendations adopted by the MTC in mid-1973.

These questions have been addressed as part of the MTC's continuing planning process. Since June, 1973, two adjustments have been made in forecast air passenger levels in the Bay Area. The latest revision, RASS II modified, identifies the following forecast passenger levels for San Francisco International Airport:

- 25.3 million passengers by 1982
- 32.8 million passengers by 1990

These forecasts reflect a slower rate of growth than originally foreseen; nonetheless, they represent substantial increases when compared to the 1974 air passenger level--17.4 million--at San Francisco International Airport (SFIA).

The airport expansion program at SFIA has resulted from recognition by the Airport's Commission of their responsibility to meet the air transportation needs of the Bay Area and the adoption by the Commission of a productive approach to fulfilling the role identified for SFIA in the RASS. The expansion program is consistent with the Commission's perception of the development required to accommodate forecast passengers at SFIA and is being undertaken with the assumption that the remaining elements of the airport system recommended in the RASS will also be implemented thereby providing the Bay Area with an effective, efficient system of aviation facilities.

2. APPROACH TO THE PROBLEM

The approach taken in preparing the analysis of the costs and benefits of the proposed expansion program has been to examine the proposed expansion program and to present, within the constraints imposed by time, costs and available technology and data, a description of both positive and negative effects of the program. An attempt has been made to present the results of the analyses objectively and to provide needed information for decision makers. This document in and of itself is merely a resource to be drawn upon in the decision-making process.

This appendix may be considered a form of summary in that the data and information presented herein are derived, in large measure from previous sections. The descriptions of the benefits and costs related to noise pollution, for example, are comprised of notable data drawn from Appendix B. Similarly, the summary with respect to air quality is taken from Appendix D. Inasmuch as these data and information have been thoroughly documented in previous sections, no attempt has been made to describe the data base or methodologies which produced these conclusions; rather, the reader is referred to the respective appendix for each of the subject areas.

This appendix also introduces new information concerning socio-economic effects. Because this information has not been presented elsewhere in the report a description of the approach to the problem of assessing these effects is presented in the section of this appendix dealing with socio-economic effects.

The summaries of airport-related impacts upon the Bay Area presented in this appendix are organized according to a generic classification system. Three broad categories -- environmental, ground access and socio-economic -- are considered. Within each of these categories, a number of topics are presented.

An attempt has been made to assemble the disparate effects into a coherent form through the use of an array of data in a matrix format. Within this matrix, the various impacts are summarized for the proposed project and for each of the alternatives to the project. The data and information presented in this matrix provide the basis for a comparison of the benefits and costs of the proposed project. For example, that portion of the matrix related to air pollution provides the basis for comparing total air pollution emissions in two areas -- "airport-related" and "vicinity." More importantly, the presentation of data in this matrix format provides a basis for summary comparisons, e.g., for air pollution emissions for various airport development configurations such as the following:

. 1974

  - Existing conditions

. 1982

  - No further development
  - Proposed development

. 1990

  - No further development
  - Proposed development without BART
  - Proposed development with BART

Thus, the relationship between three parameters -- airport-generated effects, the forecast level of air passenger demand (associated with the years of study presented) and various development alternatives, is depicted. The matrix also provides a basis for assessing benefits (in form of improvements in a specific effect or condition) and costs (in the form of degradation of a specific effect or condition).

Subsequent sections present descriptions of the notable specific effects identified above. These descriptions are followed by a presentation of the matrix and a summary of benefit and cost analysis as related to the proposed project.

3. DESCRIPTION OF THE STUDY AREA

For the purposes of this analysis, a general study area was identified within which are located areas of intensive study. The general study area corresponds to the nine-county area represented by the Association of Bay Area Governments. These counties, and their respective populations, are listed below.

County	1973 Population [1/]
Alameda	1,095,700
Contra Costa	581,200
Marin	215,700
Napa	85,200
San Francisco	687,900
San Mateo	569,400
Santa Clara	1,159,600
Solano	183,800
Sonoma	231,600
Total	4,810,100

1/ Population estimates for California Counties, Population Research Unit, Department of Finance, Sacramento, California -- August 1, 1974.

The Association of Bay Area Governments, a voluntary organization comprised of representation from each of these counties, has responsibilities for comprehensive planning for the nine-county region. Transportation planning is an obvious key element of these overall responsibilities and ABAG is actively engaged in regional transportation planning. One product of these planning efforts is the Regional Airport Systems Study (RASS) mentioned previously.

The forecasts of air transportation demand produced by the RASS effort, and subsequent updates resulting from the ABAG/MTC continuous planning process were key determinants in the development of the airport expansion program at SFIA. It appears logical, therefore, that analysis of the effects of the proposed expansion program should be made within the context provided by ABAG's geographic coverage. Thus, the nine counties listed above were selected as the general study area.

Subsequent sections will identify specific impacts and their associated areas of influence. The remainder of this appendix presents the four broad categories of airport impacts. These presentations are followed by a summary of the airport's impacts with the discussion focusing upon the airport impact matrix.

4. ENVIRONMENTAL EFFECTS

Previous appendices in this report have described in-depth analyses performed in assessing the effects of the proposed project upon the environment. For the purpose of examining the benefits and costs of the project,

the results of these and other analyses have been grouped into three broad categories--environmental, ground access, and socio-economic. Within each of these categories, specific impacts are described. These impacts, when analyzed for the forecast years and for the various alternatives, produce a comparative benefit/cost analysis. Within the environmental category, specific consideration will be given to the following areas:

- Air
- Noise
- Water
- Solid Waste
- Energy

(1) Air

Appendix D presents a thorough analysis of existing and future air quality within the airport and within its environs. The analysis was based upon estimates of air pollutants associated with airport-related activities including:

- Aircraft operations
- Ground access (on and off airport)
- Service vehicle operations
- Stationary resources

The estimates of air quality were ultimately used to determine compliance with federal and state air quality standards. Specific pollutants considered in the analysis were:

- Total hydrocarbons
- Oxides of nitrogen
- Sulphur dioxide
- Particulate matter
- Oxidant

For the purpose of the analysis of benefits and costs, a single indicator of the effects upon air quality, total emissions, was selected. Exhibit H-1 presents these emission levels for the various situations considered.

Examination of the emissions levels presented in Exhibit H-1 provides several insights into the air quality at SFIA and within its environs. First, and perhaps most obvious, a sharp decrease in non-airport related emissions is forecast for all years and all airport configurations. This trend is due to the effects of increasingly more stringent state and federal auto emissions standards.

Further examination of Exhibit H-1 indicates a significant reduction in airport-related emissions. For the region, this reduction is from approximately 105 tons/day in 1974 to approximately 45 tons/day in 1990. The results of the air quality analysis indicate a slight decrease in emissions which is attributable to the proposed project (0.5 tons/day in 1990). This decrease is a result of reduced motor vehicle idle time at the terminal curb front with the addition of the North Terminal.

It should also be noted that the alternative which assumes a BART link results in only slightly lower emissions than for other options. This is due in part to the limited effect that BART would have in replacing the private auto.

EXHIBIT H-1

San Francisco International Airport

AIR POLLUTION EMISSIONS

Year	Airport Configuration	Emissions (Tons/Day) Airport - Related		
		Airport On-Airport	Regional	Vicinity Non-Airport
1974	Existing	37.1	105.5	42.5
1982	No Further Development	32.4	54.7	11.3
	Proposed Development	31.3	53.6	11.3
1990	No Further Development	31.7	46.1	8.9
	Proposed Development W/O BART	31.2	45.6	8.9
	Proposed Development With BART	30.6	44.1	8.2

(2) Noise

Appendix B provides a description of the noise impact of aircraft operations at SFIA. Two methodologies were used in the analysis: CNEL (Community Noise Equivalent Level) and ASDS (Aircraft Sound Description System). As with the analysis of air quality effects, a number of noise impact conditions were analyzed including forecast year conditions under the various developmental alternatives.

Specific results of these analyses are presented in Exhibit H-2 and may be summarized as follows:

- CNEL methodology -- Three categories of noise impacted areas were analyzed; total area, total residential area and incompatible area. As can be seen from Exhibit H-2, the total area and total residential area impacted decreases throughout the study period. An increase in total incompatible area occurs, however, and requires some explanation for the sake of clarity. The criterion used for determining incompatibility is set by California law and that criterion becomes progressively more stringent throughout the study period. The increase in incompatible area is attributable to the progressive imposition of stricter land use compatibility/aircraft noise criteria through time (80 CNEL for 1974, 70 CNEL for 1982, and 65 CNEL for 1990). Thus, while aircraft are becoming progressively quieter thereby reducing the size of noise contours throughout the period, changes in the definition of incompatibility are also occurring and these changes produce increased areas of incompatibility.

- ASDS methodology -- Unlike the CNEL standards, the ASDS standards do not change over the forecast period; thus, the effect of an increasing percentage of quieter aircraft is reflected in the findings derived utilizing ASDS. For both total residential area and total area, the effects of seasonal wind conditions were analyzed within the context of each of the forecast years.

EXHIBIT H-2

San Francisco International Airport
NOISE IMPACT SUMMARY

Year	Airport Configuration	NOISE IMPACT									
		CNEL						ASDS			
		Incompatible Area (Acres)		Total Residential Area (Acres)		Total Area (Acres)		Total Residential Area (Acres)		Total Area (Acres)	
		Annual	Seasonal	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal
1974	Existing	3	3	1,269	2,152	6,338	8,768	532	1,292	4,070	6,057
1982	No Further Development	211	350	815	1,554	4,909	7,076	438	433	3,532	3,501
	Proposed Development	211	350	815	1,554	4,909	7,076	438	433	3,532	3,501
1990	No Further Development	481	942	481	942	3,325	5,142	399	434	3,286	3,335
	Proposed Development W/o BART	481	942	481	942	3,325	5,142	399	434	3,286	3,335
	Proposed Development W/BART	481	942	481	942	3,325	5,142	399	434	3,286	3,335

It can be seen from Exhibit H-2 that both total area and total residential area exposed to aircraft noise decrease throughout the period, a direct result of the increased percentage of aircraft operations at SFIA performed by quieter aircraft.

(3) Water

Analyses of the effects of the expansion program upon water quality are presented in Appendix E. From these analyses, two key indicators--water usage and waste water generation--were selected for inclusion in the analysis of benefits and costs. Exhibit H-3 presents a summary of the effects of the development program, and the alternatives to the program, upon these indicators for the study years.

Review of Appendix E, and of the data presented in Exhibit H-3, indicates that the water quality impact is a function of passenger levels rather than a result of the expansion program or specific alternatives. The exception to this generalization is in the area of industrial waste water. As part of the expansion program, an industrial waste treatment system will be constructed. This system will meet the stringent standards for effluent discharge into the waters of San Francisco Bay. An additional improvement in the area of industrial disposal will occur as the result of location of an outfall for the discharge of treated wastes in a position one mile offshore.

EXHIBIT H-3

San Francisco International Airport

WATER QUALITY IMPACT

Year	Airport Configuration	Water Quality Impact		
		Water Usage (MGD)	Waste Water (MGD)	
			Sanitary	Industrial
1974	Existing	1.8	0.9	1.15
1982	No Further Development	2.6	1.1	1.25
	Proposed Development	2.6	1.1	1.25
1990	No Further Development	3.4	1.6	1.20
	Proposed Development W/O BART	3.4	1.6	1.20
	Proposed Development W/BART	3.4	1.6	1.20

(4) Solid Waste

Exhibit H-4 presents data concerning the solid waste generation at SFIA throughout the study period and for the various airport configurations. These data were taken from the more detailed analysis of solid waste presented in Appendix G of this report.

As shown in Exhibit H-4, the solid waste generated at SFIA will increase throughout the study period. As for many other impacts, the generation of solid waste is a function of passenger levels and neither increased nor reduced solid waste will result from the expansion program.

(5) Energy

The consumption of energy, especially in the form of fossil fuels, has emerged in recent years as a key concern of the nation and the world. Both voluntary and compulsory controls upon the use of these fuels are topics of every day conversation. Given these circumstances, it is only logical to consider the merits of any project from the standpoint of its effects upon energy consumption.

EXHIBIT H-4

San Francisco International Airport

SOLID WASTE IMPACT

Year	Airport Configuration	Solid Waste Impact (Tons/Year x 10^3)
1974	Existing	18
1982	No Further Development	24
	Proposed Development	24
1990	No Further Development	30
	Proposed Development W/O BART	30
	Proposed Development W/BART	30

A detailed treatment of the effects upon energy consumption which will result from expansion of SFIA is presented in Appendix G. Exhibit H-5 presents data concerning the consumption of energy that may be associated with SFIA during the study period and for different airport configurations.

As can be seen from the data presented in the exhibit, energy consumption will increase significantly during the study period but will show little significant overall difference for the various airport configurations. Even completion of the BART link to the airport in 1990 achieves a reduction in energy consumption of less than one percent as compared to alternative airport configurations for the same year. This failure to realize more substantial savings results from BART's displacing other forms of mass transit rather than serving as an effective alternative to the personal auto.

As noted in Appendix G, increased consumption of natural gas for heating will occur as a result of the expansion program. This will be partially offset by the reductions in gasoline consumption by idling autos due to curb frontage improvements.

EXHIBIT H-5

San Francisco International Airport

ENERGY IMPACT

Year	Airport Configuration	Energy Consumption (BTU's/Yr. x 10^{12})
1974	Existing	82
1982	No Further Development	98
	Proposed Development	100
1990	No Further Development	106
	Proposed Developmet W/O BART	108
	Proposed Development W/ BART	107

Further, this increase in energy consumption is a very small portion of the total energy consumption associated with the operation of the airport. Its level of magnitude is less than one-half of one percent of the total energy consumed.

As would be expected, the major component of the energy impact of SFIA results from aircraft operations. With regard to the consumption of aviation fuel, it can be reiterated from Appendix G that energy consumption, although increasing throughout the study period, will be more efficient due to the use of widebodied commercial aircraft.

5. GROUND ACCESS EFFECTS

Ground access is a key issue in any consideration of the expansion program at SFIA. The location of the airport, on a six mile wide peninsula places constraints upon access to one of the area's large traffic generators. It becomes critical, therefore, to analyze the effects of major airport expansion upon ground access in the area. Appendix C provides detailed analyses of ground access effects. As in the previous section concerning environmental effects, the analysis of benefits and costs is based upon the use of key indicators of ground access effects drawn from this previous work. The specific indicators presented in this section are:

- Total vehicle movements
- Number of locations over capacity
- Percent curb frontage occupied
- Percent access by transit

Each of these is described below.

(1) Total Vehicle Movements

A key indicator of actual traffic conditions is produced through simulation of vehicular movements. These movements, generated by air passengers, non-air passengers, and employees at the airport, were simulated for design day conditions at SFIA in 1974, 1982, and 1990. The results of these simulations are described in Appendix C and are summarized in Exhibit H-6.

The principal observation to be made with respect to the data presented in this exhibit is that the data clearly show a substantial increase in total vehicle movements for each of the study years. This increase, using 1974 as the base year, is 48.4 percent for 1984, 107.2 percent for 1990 (without BART) and 96.6 percent (with BART).

In order to understand this seemingly inexorable increase in vehicle movements and the relationship between vehicle movements and the expansion program, the nature of vehicle movement

EXHIBIT H-6

San Francisco International Airport
GROUND ACCESS IMPACTS

Year	Airport Configuration	GROUND ACCESS IMPACTS: Total Vehicle Movements ($\times 10^3$)	Airport-Related VMT ($\times 10^6$)	Number of Locations Over Capacity	Percent Curb Frontage Occupied	Percent Access By Transit
1974	Existing	98.8	1.97	6	83	9
1984	No Further Development	146.6	3.26	6 1/	100	11
	Proposed Development	146.6	3.26	6 1/	59	11
1990	No Further Development	204.7	4.70	15 1/	128	12
	Proposed Development W/O BART	204.7	4.70	15 1/	75	12
	Proposed Development W/BART	194.2	4.45	13 1/	71	17

1/ Assumes completion of I-380 and related improvements.

generation must be analyzed. These vehicle movements are produced by trip-taking from three sources--air passengers, non-air passengers and employees. The key element among these three is the level of air passengers because this element drives the growth of the remaining two. Further, it has been shown in Appendix A that increases in air passengers will occur independently of the expansion; thus, if air passengers and the concomitants, non-air passengers and employees increase with or without the expansion program, it follows that total vehicle movements can increase accordingly. To this extent then, it may be stated that forecast increases in vehicle movements are not a result of the expansion program and are not, therefore, a cost to be associated with the program.

(2) Number of Locations Over Capacity

Appendix C also provides analyses of a variety of ground access capacity factors. Included among these are:

- On-airport intersection capacities
- Off-airport intersection capacities
- Weaving capacity--main entrance road
- Public parking sufficiency
- Off-airport highway capacities

The capacity items analyzed provide the basis for the conclusions presented in this subsection. Exhibit H-6 indicates the number of locations over capacity for each of the study periods and airport configurations. (The analyses for 1982 and 1990 assumed completion of I-380 and related improvements.) These locations include intersections and road segments.

As with certain ground access indicators previously discussed, the number of locations over capacity has no causal relationship with the expansion program. Traffic generation is largely a function of air passenger demand and not terminal configuration; thus, the number of locations over capacity in 1984 are equal for both airport configurations. This same equality prevails in 1990 with the exception of the configuration featuring BART access. The presence of the rapid transit link would alleviate the over capacity conditions at two locations.

(3) Percent Curb Frontage Occupied

As part of the study of ground access effects, an analysis of curb frontage for both the enplaning and deplaning roadways fronting the existing and proposed terminals was necessary.

This analysis showed that deplaning curb frontage need was the more critical than frontage for enplaning passengers due to higher demand volumes and longer dwell times at deplaning curbs. As noted in Appendix C, deplaning curb frontage is a most vulnerable component of the ground access system and has a high probability of delays.

The analysis of curb frontage was performed using an accepted standard for practical curb frontage capacity. This practical capacity equals 70 percent of the available capacity and is used because demand in excess of 70 percent usually results in double parking, illegal use of reserved curbs, or excessive walking distances.

Exhibit H-6 presents the results of the deplaning curb frontage analysis for the various alternatives. Review of these data shows the following:

- Under 1974 existing conditions, curb frontage occupancy is 83 percent and exceeds practical capacity by 13 percent.

- The "no further development alternative" for 1982 and 1990 results in increasing capacity problems. In 1982, for example, actual occupancy would equal available space, if possible. In 1990, the potential percent occupancy (128%) exceeds both practical capacity and available capacity.

- With the completion of the north terminal as part of the expansion program, the problem of curb frontage is resolved. Percent occupancy for 1982 with proposed development is an excellent 59 percent, while the percent occupancy in 1990 is 75 percent (without BART).

From these observations it may be concluded that, with respect to curb frontage requirements, a substantial need exists at the present time and this need becomes increasingly critical throughout the study period. The expansion program will resolve this problem by providing needed curb frontage; thus, from the standpoint of this specific surface access indicator the expansion program will provide a definite benefit -- with reduction of traffic congestion and delay attributable to deplaning curb frontage deficiencies.

(4) Percent Access by Transit

Exhibit H-6 also presents data concerning the percent access by transit. Two observations may be made from these data. First, the percent access by transit shows an increase throughout the study period but this increase will occur independently of the expansion program. Second, the BART link to SFIA will increase the percent access by transit but increase is not large inasmuch as the BART would divert only a small percentage of access by auto.

6. SOCIO-ECONOMIC EFFECTS

The analysis of socio-economic effects is unlike the preceding treatments of environmental and ground access effects in that socio-economic effects are not discussed elsewhere in this document. As a result, in this section a description of the methodologies and processes used in analyzing socio-economic effects must be combined with the analysis of benefits and costs.

(1) Introduction

This section provides a description of socio-economic effects attributable to continued growth in air transportation demand at SFIA as identified previously in this appendix. Several indicators of these effects are analyzed including the following:

- Capital cost
- Employment effect
- Payroll effect
- Expenditure effect
- Induced growth

In the performance of this analysis, the data and information presented in the Draft Environmental Report, San Francisco International Airport (August, 1973) served as useful references. Other existing studies were utilized as feasible. As with other sections of this document, the

assessment of socio-economic effects necessitated original data gathering and analyses which were performed as necessary. Subsequent sections summarize the various analyses with specific reference to the indicators listed above.

(2) Capital Costs

Capital cost for the expansion program were simply derived from data presented in the Draft EIR and back-up documentation. The capital cost of the proposed expansion has been estimated at $390.0 million. The cost of extension of the BART link to the airport has been estimated at $251.0 million. Further discussion of these capital costs is deferred for treatment in a subsequent section of this appendix.

(3) Employment Effect

The Draft EIR presented an analysis of employment impact which drew heavily from two sources:

- Wilsey and Ham, The Effect of Aviation on Physical Environment and Land-Uses, 1971
- William Goldner, et. al., Economic and Spatial Impact of Alternative Airport Locations, 1971.

These studies were prepared as part of the Regional Airport Systems Study (RASS) sponsored by the Association of Bay Area Governments.

The employment data presented in these documents was generally provided by a data base developed from a 1965 survey conducted by the Bay Area Study Commission (BATSC) and many of the conclusions presented in the Draft EIR, with regard to employment impact, were based upon 1965 data and extrapolations therefrom.

An effort was undertaken as part of this study to update the data base for employment in airport-related sectors of the Bay Area economy. Included in these sectors were:

- Air transportation
- Concessionaires
- Hotel/motel
- Government

The primary instrument employed to update the data base was a mail-out questionnaire which was sent in January, 1975 to individuals and firms listed on SFIA's airport tenant list and then a follow-up mailing of the questionnaire to non-respondents in the first mail-out. This effort produced 76 responses from a population of 101. The data and information produced by this survey were supplemented by data received in partial returns from a similar survey conducted by SFIA's public relations department in August, 1974. Information concerning hotels and motels within a 2.5 mile radius of SFIA was provided by the San Mateo County Development Association and cross-checked with hotel/motel respondents to the 1975 survey.

The results of these various data collection efforts were combined and tabulated. From reported employment data, employment estimates were prepared for non-respondents based upon similarities to respondent firms. Exhibit H-7 presents the employment data produced from these for SFIA activities.

The basic employment level associated with the airport was compared with the projections of employment based upon data presented in the Draft EIR. The projections for air transportation employees (approximately 20,200) in the EIR closely corresponded to air transportation employment (20,974) reported in 1975. The addition of 1975 concessionaire employment produced a significant difference (22,365) as compared to the air transportation category used in 1965.

A more significant difference appeared in hotel/motel employment. Interpolation of a 1975 value for the EIR data produces an estimated hotel/motel employment of approximately 1,000. The estimate developed from the 1975 survey (2,164) is more than double the 1965 based value and is indicative of rapid growth of hotels and motels in the area of the airport.

EXHIBIT H-7

San Francisco International Airport

AIRPORT-RELATED EMPLOYMENT--1975

Category	Employment
Air Transportation	20,974 [1/]
Concessionaires	1,434
Hotel/Motel	2,164
Government	1,860 [2/]
Total	26,432

1/ Includes 7,990 United Airlines Maintenance Division employees.

2/ Includes 250 U.S. Coast Guard Air Station personnel.

A smaller disparity exists between the 1975 level of government employees (less the U.S. Coast Guard personnel who were judged to be unrelated to commercial air transportation operations of SFIA). The 1975 level was 1,608 while the 1965-based interpolation was approximately 1,200.

Given the disparities between 1975 survey based employment levels and interpolations of 1965 projections, it was decided that projections of employment based upon 1982 and 1990 air passenger levels should reflect emphasis on 1975 empirical evidence. Employment in each of these four categories was assumed to have a relationship to annual air passengers. Ratios were developed for each of the employment classifications as a function of 1974 air passengers (17.4 million). Employment levels in each classification were then expanded as a function of passenger levels for 1982 (25.3 million) and 1990 (32.8 million) based upon the ratio of passengers to employees identified for 1975. The exceptions to this general rule were air transportation and government. For air transportation two ratios were developed; the first, for employment other than United Airlines' maintenance; the second, for United Airlines' maintenance employment. Non-maintenance ratios

of 1,540 passengers per employee in 1982 and 1,800 passengers per employee in 1990 were used for these respective years. These ratios are extrapolations of 1965 and 1975 data points. An extrapolation of maintenance employees was prepared independently and was based upon the 1965 and 1975 data points.

Government employment was extrapolated as a function of passenger levels from a base number which excluded the 252 U.S. Coast Guard personnel. These personnel were assumed constant throughout the study period and simply were added to the passenger-based projections of other government employees for 1982 and 1990.

Exhibit H-8 presents the projections of airport-related employment based upon 1982 and 1990 passenger levels. These projections show overall increases in employment of 7,218 from 1975 to 1982 and 13,055 from 1975 to 1990.

The responses to the survey also produced data concerning the geographic distribution, by county of residence, of employees. This distribution was as follows:

- San Mateo County--50.7 percent
- San Francisco County--17.0 percent
- Alameda County--13.7 percent
- Santa Clara County--9.8 percent
- Contra Costa County--1.9 percent
- Masin County--1.8 percent
- Other--5.1 percent

EXHIBIT H-8

San Francisco International Airport

PROJECTIONS OF AIRPORT-RELATED EMPLOYMENT

Classification	Employment 1982	1990
Air Transportation	25,829	29,422
Concessionaires	2,085	2,703
Hotel/Motel	3,146	4,079
Government	2,590	3,283
Totals	33,650	39,487

As can be seen from these data, SFIA exerts a powerful employment effect on four counties in particular -- San Mateo, San Francisco, Alameda and Santa Clara. It appears reasonable to assume that the existing geographic distribution of employees by residence is an indicator of future distributions. Combining that assumption with projected levels of employment leads to the conclusion that SFIA will exert an increasingly significant employment effect throughout the study period.

(4) Airport-Related Payroll Effect

The 1975 survey included collection of data concerning airport-related payroll. These data comprised the basis for the estimates of total airport-related payroll provided in Exhibit H-9.

The projections for 1982 and 1990 payroll were developed by applying projections of 1982 and 1990 employment levels to projected salary levels for each classification of employees. The projected salary levels were derived from the 1975 survey data. The payroll effect generated by SFIA is obviously very significant for the Bay Area and will increase in importance in the future. By 1990, for example, it is anticipated that airport-related functions will be a billion dollar industry in terms of payroll generation.

EXHIBIT H-9

San Francisco International Airport

AIRPORT-RELATED PAYROLL

Classification	Payroll ($ x 10^6) 1975	1982	1990
Air Transportation	374.0	621.8	918.2
Concessionaires	15.0	29.4	49.4
Hotel/Motel	13.2	26.0	43.7
Government	19.6	36.8	60.4
Totals	421.8	714.0	1071.7

(5) Expenditure Effect

Economists have long recognized the existence of an expenditure, or multiplier effect. The basic premise upon which the effect is predicated is the process of consumer spending which generates additional, or multiplied, spending. The purpose of analyzing the expenditure effect, through use of a multiplier is to determine the overall income injection into the economy of the study area as a result of wage and salary earnings and spending habits.

For the purposes of illustrating the potential expenditure effect attributable to airport-related payrolls, a multiplier of two was used. This means simply that each dollar of payroll expenditure generates a total re-spending of one dollar. Such a multiplier is commonly used in studies of this kind. (See for example Waldo & Edwards, Inc., The Economic Impact of Los Angeles International Airport on Its Market Area.

Application of the multiplier to the payroll data presented in previous paragraphs produced the total payroll expenditure effect shown in Exhibit H-10. The projected expenditure effect in 1990, for example, shows that airport-related payrolls will comprise in excess of $2 billion in injections to the Bay Area's income stream.

EXHIBIT H-10

San Francisco International Airport

AIRPORT INDUCED EXPENDITURE EFFECT

Year	Airport Configuration	Expenditure Effect ($ x 10^6)
1974	Existing	843.6
1982	No Further Development	1,427.2
	Proposed Development	1,427.2
1990	No Further Development	2,142.8
	Proposed Development W/O BART	2,142.8
	Proposed Development W/ BART	2,142.8

A second expenditure effect was analyzed which is not directly related to airport employment but is related to the presence of the SFIA and the number of passengers the facility serves. The majority of passengers (60 percent) using SFIA are non-residents of the Bay Area; thus, they must be considered as visitors or tourists. As such, they make expenditures for accommodations, food and other items in the area, and these expenditures are injections of non-local dollars into the local economy.

Data provided by the San Francisco Convention and Visitors Bureau indicate an average length of convention of 4.5 days and average daily expenditures by conventioneer of $55.39. These data were assumed as applicable to visitors passing through SFIA, and estimated expenditures by these visitors, while in the Bay Area, were developed. These estimates are as follows:

- 1974--$1.3 billion
- 1982--$2.0 billion
- 1990--$2.5 billion

The study of Los Angeles International Airport's economic impact cited previously used a multiplier of 1.45 to determine the overall economic impact of tourist and recreational expenditures on the local economy. Applying this same multiplier to the SFIA related data gives the estimates of the overall expenditure effect attributable to tourists and visitors passing through SFIA:

- 1974--$1.9 billion
- 1982--$2.9 billion
- 1990--$3.6 billion

Combining these expenditure effects with the airport-related employment expenditure effects indicates that SFIA exerts a tremendous overall expenditure effect on the area. The magnitude of this effect is estimated to be as follows:

- 1974--$2.7 billion
- 1982--$4.3 billion
- 1990--$5.7 billion

(6) Airport-Related Local Taxes

The presence of an industry or other major employers such as SFIA is often viewed as a mixed blessing. Such an employer does provide jobs and incomes. On the other hand, the presence of the industry and its employees imposes a burden upon local governments with respect to the provision of public services such as police protection, sewer service and schools. While it is not the purpose of this study to resolve question concerning the desirability of growth, two indicators of the effects of growth are presented in this and the following section.

The imposition of a demand for public services should be considered within a context which includes offsetting payments, in the form of taxes, for those services. Data provided representative of the SFIA indicate that airport tenants paid $14,566,146 in local taxes in 1974.

While no reliable methodology is available for projections of future tax payments (due to the probability of basic changes in the tax structure during the forecast period), general projections were made to serve as an indicator of future tax payments. These projections were based upon the ratio of local tax payments to number of employees. On the basis of this ratio, local tax payments of $18.5 million and $21.8 million annually were projected for 1982 and 1990, respectively. These projections, it should be noted, are for employer paid local taxes and do not include the local tax payments made by employees.

(7) Airport-Related Induced Residential Growth

Induced growth is an important impact which must be considered as part of the overall impact analysis. For the purposes of this section, airport-induced residential growth was considered as an indicator of the overall effect of the growth in passenger levels and concomitant increased employment at SFIA.

The Draft EIR contained data derived from reports by Wilsey & Ham, and Goldner, et.al., cited previously. These data showed that a ratio of 1.25 local service employees was required for each basic employee. Thus the addition of approximately 13,000 airport-related employees during the study period would be expected to generate approximately 16.4 thousand local serving employees. The combined addition of these airport-related and local-serving categories would total 29.4 thousand.

The Draft EIR also produced data showing that each job was anticipated to add approximately 1.5 persons to the region's population and that each three persons added to the population generated the need for one residence. Applying these coefficients to the airport-related and local-serving employment increases produces a projected population increase of 44.1 thousand and an associated increase in residences of 14.7 thousand by 1990.

7. SUMMARY OF BENEFITS AND COSTS

The preceding sections of this Appendix have presented summary descriptions of the effects of the proposed expansion program. Specific indicators in three categories -- environmental, ground access and socio-economic -- have been described.

The purpose of this section is to provide, based upon a synthesis of the information presented in previous pages, an understanding of the benefits and costs of the airport expansion program. The achievement of such understanding requires a clear perception of the purpose to be served by the expansion program.

As noted in the introductory section of this appendix, recommendations were set forth in the RASS which identify SFIA as the keystone of the Bay Area's air transportation system. Consistent with this role are the assignments of air passenger demand to the airport as set forth earlier. The expansion program is intended to accommodate that level of demand in an efficient, effective and environmentally acceptable fashion.

While it may be hypothetically stated that existing facilities at SFIA can accommodate the increased demand levels of 1982 and 1990, information presented in Volume I of this report clearly shows that applying reasonable criteria for terminal sizing versus air passenger demand indicates the need for terminal expansion at SFIA. This expansion will permit the accommodation of increased demand without compromising service to the traveling public. The expansion program must be viewed and evaluated within this context.

Critical factors to be considered in this evaluation include the benefits and costs of the program. For the purpose of summarizing these benefits and costs, the data and information presented in previous sections of this appendix have been assembled and arranged in a matrix format. Exhibit H-11 depicts

this matrix. Review of the elements of this matrix, in conjunction with the preceding narrative, provides the basis for the following summary comments insofar as the benefits and costs of the project are concerned:

- Environmental -- The benefits and costs of the project as evidenced by the environmental indicators presented herein must be assessed within the context provided by a question: Does the expansion program derogate the environment of the area? To that question, on the basis of information presented in this document, the answer must be: No, the program does not derogate the environment; rather, expansion of the terminal provides an opportunity for improvements which will not only accommodate air transportation demand efficiently and effectively, but also does so in a manner which enhances the environment. Specifically, and with reference to Exhibit H-11, direct environmental benefits are attributable to the expansion program. These include:

  - Improved air quality as a result of less idle time for autos in the terminal area

  - Improved quality of industrial waste water effluent as a result of construction of a new treatment facility.

  These improvements are especially significant when it is remembered that the expansion program will provide for accommodation of a near doubling in passenger levels.

- Ground Access -- Within the same general context; evaluated above, that is, does the program derogate ground access conditions; the answer must also be no. The ground access analysis showed that certain on-airport difficulties will persist and intensify throughout the forecast period unless the expansion program or similar improvements are consummated. Specifically, the deplaning

curb frontage condition is overloaded at present. The expansion program will provide essential improvements in this area. Without such improvements, forecast passenger levels would produce chaotic conditions of overcrowding in this area.

Other facets of the ground access analysis are noted in the matrix. In each of these instances, it is important to note that any anticipated derogation of the quality of service is attributable to forecast travel demand and not to the expansion program. Further, it should be noted that the expansion program is limited in scope and could not be expected to alleviate certain of these difficulties; rather, such improvements would occur as independent developments.

Socio-economic -- Two categories of socio-economic impacts should be assessed in evaluating the expansion program. First, the capital cost should be weighed against the expected improvements in facilities and conditions. Second, ancillary socio-economic effects such as employment and expenditures should be considered.

Incurrence of the capital costs of the expansion program will permit the maintenance of a reasonable terminal sizing/passenger ratio throughout the forecast period. As noted in Volume I, Chapter I, the existing ratio of boarding passengers per square foot of space is 22.4:1.0. Without expansion, this ratio would increase to an untenable 42.4:1.0 in 1990; thus, the expansion program is necessary to maintain the viability of SFIA as the Region's major air carrier facility if levels of service are not to deteriorate significantly.

With regard to ancillary socio-economic effects, e.g., employment, income, and expenditures, the tremendous impacts of SFIA upon the Bay Area have been illustrated. While it must be conceded that many of these impacts are functions of air transportation demand and not direct results of the expansion program, it must also be noted that the expansion program will enhance the position of SFIA as a major employer and economic influence in the region.

On balance it may be said that negligible negative effects, or costs, are attributable to the expansion program other than the obvious capital costs to be incurred. Weighing these capital costs within the context of continued viability of SFIA as a major hub airport fulfilling its assigned regional role, and reviewing the environmental, ground access, socio-economic and air travel benefits of the program indicates the desirability of the expansion program.

EXHIBIT H-11

San Francisco International Airport

MARY OF BENEFIT AND COST INDICATORS

Year	Airport Configuration	Passenger Demand	AIR EMISSIONS Tons/Day			Inco		SOCIO-ECONOMIC				
			Airport-Related		Vicinity							
			On-Airport	Regional	Non-Airport	Ann	Percent Access By Transit	Capital Cost $x10.8	Airport Related Employment $x10^3$	Airport Related Payroll $x10^9$	Airport Related Expenditures $x10^9$	Airport -Induced Residental Households $x10^3$
1974	Existing	17.4	37.1	105.5	42.5	3	9	-	28.4	421.9	843.6	-
1982	No Further Development	26.2	32.4	54.7	11.3	211	11	-	33.7	713.6	1427.2	8.2
	Proposed Development	28.2	31.3	53.6	11.3	211	11	390.0	33.7	713.6	1427.2	8.2
1990	No Further Development	33.0	31.7	46.1	8.9	481	12	-	39.5	1071.4	2142.8	14.7
	Proposed Development W/O BART	33.0	31.2	45.6	9.9	491	12	390.0	39.5	1071.4	2142.8	14.7
	Proposed Development W/BART	33.0	30.6	44.1	8.2	481	17	641.0	39.5	1071.4	2142.9	14.7

EXHIBIT H-11

San Francisco International Airport

SUMMARY OF BENEFIT AND COST INDICATORS

IMPACTS

Year	Airport Configuration	Passenger Demand	ENVIRONMENTAL: AIR: EMISSIONS Tons/Day: Airport-Related: On-Airport	Airport-Related: Regional	Vicinity: Non-Airport	NOISE: CNEL: Incompatible Area Acres: Annual	Incompatible Area Acres: Seasonal	Total Residential Area Acres: Annual	Total Residential Area Acres: Seasonal	Total Area Acres: Annual	Total Area Acres: Seasonal	ASDS: Total Residential Area Acres: Annual	Total Residential Area Acres: Seasonal	Total Area Acres: Annual	Total Area Acres: Seasonal	WATER: Water Usage MGD	Waste Water MGD: Sanitary	Waste Water MGD: Industrial	SOLID WASTE Tons/Year x10³	ENERGY BTU's/Year x10¹²	GROUND ACCESS: Total Vehicle Movements x10³	Airport-Related VMT x10⁶	Number of Locations Over Capacity	Percent Curb Frontage Occupied	Percent Access By Transit	SOCIO-ECONOMIC: Capital Cost $x10.6	Airport Related Employment x10³	Airport Related Payroll $x10⁶	Airport Related Expenditurea $x10⁶	Airport -Induced Residential Households x10³
1974	Existing	17.4	37.1	105.5	42.5	3	3	1266	2142	6338	6766	532	1262	4070	6057	1.8	0.6	1.2	16	62	68.8	1.67	8	63	6	-	26.4	421.6	843.6	-
1982	No Further Development	26.2	32.4	54.7	11.3	211	350	615	1554	4909	7076	436	433	3532	3501	2.8	1.1	1.3	24	68	146.6	3.26	8	100	11	-	33.7	713.8	1427.2	6.2
	Proposed Development	26.2	31.3	53.6	11.3	211	350	815	1554	4606	7076	438	433	3532	3501	2.6	1.1	1.3	24	100	148.6	3.26	6	56	11	390.0	33.7	713.6	1427.2	6.2
1990	No Further Development	33.0	31.7	46.1	6.6	461	642	461	642	3325	5142	366	434	3266	3335	3.4	1.6	1.3	30	106	204.7	4.70	15	128	12	-	36.5	1071.4	2142.8	14.7
	Proposed Development W/O BART	33.0	31.2	45.6	6.6	481	642	461	642	3325	5142	366	434	3268	3335	3.4	1.6	1.3	30	108	204.7	4.70	15	75	12	360.0	39.5	1071.4	2142.6	14.7
	Proposed Development W/BART	33.0	30.6	44.1	6.2	461	642	461	642	3325	5142	366	434	3268	3335	3.4	1.6	1.3	30	107	164.2	4.45	13	71	17	841.0	39.5	1071.4	2142.6	14.7